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Compression Leverage Fractures of the Ankle Joint

(Pott's Fracture)

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COMPRESSION LEVERAGE FRACTURES OF THE ANKLE JOINT

By JAMES H. STEVENS, M.D., Boston, Massachusetts

FRACTURES of the ankle joint which have been called Pott's in England and America since the days of Percival Pott and Dupuytren's by the French, have excited more discussion and have been the cause of more misunderstanding as to the pathology than almost any other injury and today the definition of a Pott's fracture will to a great extent depend upon the individual understanding of what constitutes the essentials of this extremely common injury.

If one studies the subject intensively he can hardly fail to arrive at the conclusion that the injury which at first seems so simple is in reality a rather complex problem involving an understanding of the mechanics of leverage, the distribution of stresses, and the consideration of a number of apparently entirely different pathological entities. It illustrates to our mind the difficulties encountered when the name of a man, no matter how eminent, is attached to a supposedly definite pathological condition, and an attempt is made to define such a pathology so that it will fit specifically each and every case. There are hardly two men who will agree on a definition and no definition which is at present accepted conveys to the mind of any intelligent observer either the cause or the nature of the trauma.

The accepted definition of a classical Pott's fracture is a fracture of the fibula 2 to 4 inches above the joint, and an accompanying fracture of the internal malleolus or a ruptured internal lateral ligament. Few observers however in speaking of Pott's fracture confine their classification to any such a close definition and should they do so they would have to rule out the greater number of ankle fractures because they do not conform to any such definition; while these fractures have sustained, nevertheless, exactly the same stresses in production and present from all practical view-points the same pathology and give the same prognosis. The description of the so-called classical type is a good description of one variety; and a glance at our table representing the sequence of events in 249 injuries at or near the ankle joint will show that the description is of the type which is numerically the smallest. In fact, it is surprising how few cases of this type occur in the sum total of all cases of fracture at or about the ankle joint. Only 16 of 249 cases conform to this description and only 28 cases show a high fracture of the fibula of either inversion or eversion types. Are we to rule out all the others? Is it an essential or a matter of importance that the fibula be broken high? If so, we shall have to rule out the greater number of these fractures.

Is it important or essential that the internal malleolus be broken? If so, we shall have to rule out the larger percentage of cases.

Is it essential that the internal lateral ligament be ruptured? If so, we shall have to exclude most of the cases. In our opinion and in this article, we hope to prove that the internal lateral ligament is rarely ruptured. This view is contrary to that held by most of our colleagues.

As we have said, we have the definition and the description of Percival Pott, but he described a fracture of the fibula high up and a broken internal lateral ligament and not the classical type which is assumed to be his. His type, if it exists at all, is rarer than the classical type.

Both Pott's and Dupuytren's observations upon the nature of this lesion were made in the pre-X-ray days and there has been altogether too much of a tendency among certain surgeons to think that these two men said the last word in regard to ankle fracture. All cases must fit perfectly into the classical description, otherwise they may not be Pott's. In the first place, we are told, there is the case of the simple fracture of the fibula at its lower end without displacement which is not a Pott's because there is no breaking of the internal malleolus and no rupture of the internal lateral ligament, both of witch in reality would be pretty much the same thing. One could easily imagine a fracture of the fibula at its lower end by a comparatively slight hammer blow (direct violence) which would produce nothing except a fibula fracture without any dislocation of the astragalus and with little or no damage to soft tissue, especially to the ligaments, tendons and sheaths closely packed about the ankle joint. There would be little disturbance of the articular surface of the joint itself. A similar injury could happen to the internal malleolus as well or to both at the same time and yet have comparatively slight influence on the joint surface or on the surrounding soft tissues. Obviously such an injury, the blow or the pressure producing it being direct and limited in area (as a hammer blow or a blow from a rock or a pressure in which the ankle is caught between the two surfaces exerting pressure upon it) unless the force were greatly in excess of the usual probably would not do sufficient damage to dislocate the foot.

Many of us have seen accidents of this type in trench digging where rocks have fallen or have been blasted, and have struck the outer side of the fibula producing a simple fracture of the bone. Even when the line of fracture runs into the joint, the ligaments are seldom ruptured. There is little tendency to displacement, little damage to synovia, not much bleeding into the jont, little trauma to tendons and tendon sheaths, and there is rarely any disturbance of the annular ligaments.

The reaction to inflammation is not pronounced, and there is little œdema. Such an injury is not to be classified as a Pott's fracture. The transverse ligament is intact, therefore the tip of the external malleolus can not become displaced outward. The inferior tibiofibular ligaments are intact, therefore, the foot will not become dislocated. There is little damage other than the solution of bony continuity which is of little importance. The prognosis in such a fracture would always be good.

But when a man steps from a curbing running to catch a train or a car and his foot strikes an uneven surface in the pathway, it turns outward. There is impact behind the force and the weight of the man is added to the impact. The foot turns outward and a leverage results—a tremendous leverage. The fibula breaks at the joint surface usually but occasionally above it as in the classical type.

The inferior tibiofibular ligaments are stressed and are always more or less damaged; the tip of the fibula swings outward and usually backward, as we shall show; there is widening of the mortise of the ankle joint and whether or not the ~~fracture~~ occurs there disloca
is the potentiality of dislocation.

There is a great deal more damage than in the case of the direct blow and there is a tremendous injury to the joint itself which is not present in the other case.

One is ephemeral. The other is dynamic and its effects are lasting. The fibula is broken in both. The X-ray clearly demonstrates this and the picture is much the same, a break at the level of the joint. But the real injury is not to be seen in the X-ray. In one there is little injury save a solution of bony continuity and it is not a Pott's fracture. In the other, the X-ray does not show them but the essentials are all there, the ligamentous rupture which may be profound and therefore the potentialities of widening of the mortise and dislocation of the foot which while it may not have occurred is nevertheless a possibility.

There is inflammatory exudate which organizes and restricts motion. There is a tearing of connective tissue which binds these tendon sheaths to the periosteum and keeps them firmly in their proper places. There are torn or stressed ligaments and tendons and a traumatized synovia which fills the joint full of blood and effusion. There is damage to the annular ligaments which permits dislocation of the tendons from their proper grooves. These are the most important factors which go to form the pathology of an ankle injury and it is no wonder that we get restricted motion and many times permanently damaged joints as a result of the present treatment by immobilization over long periods of time.

It is also a fact that these ankles damaged for long periods of time or even permanently

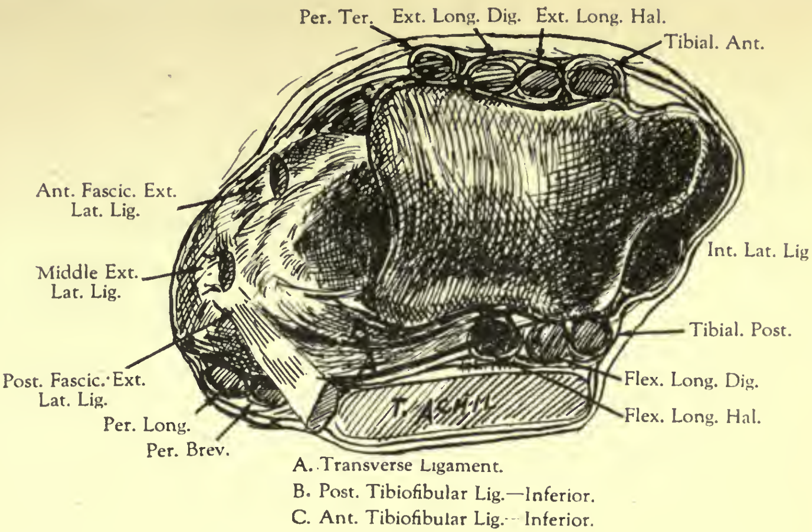

Fig. 1. Note the intimate relations of all these tendons and ligaments to the bone, and how impossible would be any serious injury without disturbance of all these tendons and tendon sheaths and especially their attachments to the periosteum. Note the relation of the anterior tibiofibular ligament and the posterior tibiofibular ligament and the transverse which is inserted nearer the tip of the fibula and forms really a part of the posterior surface of the articulation.

are almost as common a sequel of the lesser injuries as they are of those presenting an apparently much more serious pathology; and this is true of all these fractures at the ankle joint except the breaks from direct violence.

Look at Figure 1 representing the relations of the tendons to this closely packed space, and visualize if you can any leverage injury sufficient to fracture these bones which would not also greatly injure these movable tendons. This is a Pott's fracture, so designated without regard to where the fibula may be broken or whether or not there is implication of the internal malleolus or the internal lateral ligament.

If the dislocation is reduced and there remains a widening of the tibiofibular astragaloid mortise, it is clear that we shall have a wabbly foot and a foot which will have a tendency to the valgus position. If the fractured bones unite perfectly, the dislocation having been properly reduced and all the ligaments which were injured healed (a little thickened, perhaps, but nevertheless united and as strong as before); and we have paid no attention to the normal mechanism of the foot or the purposes for which it was made; and the tendons, tendon sheaths, torn annular ligaments, and synovia of the joint itself have reacted exactly as they will always react in the presence of a tremendous trauma; how can we expect to have a normal foot except at the expense of weeks and months of effort toward recovery of that motion which should never have been lost from the first?

If the ordinarily accepted definition is only a definition of one variety of the fracture, if that variety is one which while more severe is numerically less than other types, and if by its very wording the definition excludes absolutely the other types, then it is clear that the definition has not only failed as such, but has failed infinitely in that it has befogged the whole subject.

If we are to cling to this old nomenclature, let us see if we can frame a definition. In all the various descriptions there is uniformity on one point, the fracture of the fibula. But it is evident to anyone who has studied this subject that the fracture of the fibula is not the all-important feature.

If you will glance at Figure 15 you will see the X-ray of a fracture of the internal malleolus and a dislocation of the astragalus outward made possible by the rupture of the inferior tibiofibular ligaments. Now by Pott's definition, this is certainly not a Pott's and any definition which we might have substituted that included agreement on this one point of uniformity would be no more satisfactory. There is no fracture of the fibula at all in this case, although the injury was produced by eversion. There is dislocation outward and every other essential of a Pott's is present, including prognosis, except the fracture of the fibula.

If you will glance at Figure 11, you will see the X-ray of an injury produced also by eversion, or eversion and rotation, with ruptured inferior tibiofibular ligaments, with outward dislocation of the astragalus, with all the soft injuries exactly as produced by a Pott's, and without any fracture of the bones at all. Such an injury, while not a severe type, is nevertheless an injury which must be treated conservatively; and is an injury which unrecognized and untreated or improperly treated will give quite as bad a result as any of the ordinary ankle injuries.

We therefore contend that it is clearly impossible to frame a definition to include all these various types which are clearly of the same etiology, presenting the same essential features in varying degrees of severity, the same disability to the ankle joint, including even destruction of mortise and dislocation of the foot; and presenting the same prognostic importance; under the blanket name of any one man without specifying the individual features. Also all other essentials being the same in varying degrees, even the prognosis, it is equally absurd to classify only as Pott's those fractures of the fibula high up or at any level, with a broken internal malleolus as well; since none of these types of fracture present any feature of any importance different from the others except in the degree of the injury.

The pathology of the bones varies greatly.

The pathology of the soft parts varies in degree at least according to the severity of the individual injury.

Are there then no features common to all these injuries at the ankle joint by the use of which in our terminology we may instantly visualize the character of the injury without knowing specifically the individual pathology and by which we shall be able to separate the injuries definitely from the lesser ones due to local and direct violence?

We believe that if we classify these injuries under the terminology which we have used in this paper, abandoning the older nomenclature while still giving to Pott and Dupuytren the credit which is theirs, we shall be able to group fractures on a scientific basis since etiologically there are certain mechanical features common to all; and if we study these stresses to which the ankle is subjected in the production of this type of injury we shall find, we believe, reason for this classification.

1. Compression is the most important feature and is always present in every case, the weight of the man (static compression) plus the infinitely greater compression stress due to impact. These breaks at the ankle are rarely pure compression breaks which we contend is true of the fractures of the lower end of the radius commonly called Colles'; but the compression of the astragalus firmly held against the tibiofibular mortise which prevents a turning movement while at the same time causing the locking of all the tarsal articulations, determines to a great extent the character of the injury.

2. Leverage. There is a transverse breaking strain due to the stresses produced by leverage with compression on one side of the breaking bone and tension upon the other.

There is also a semitortional stress due to the fact that this leverage is exerted simultaneously in two distinct lines of force.

If we subdivide this classification into eversion and inversion types, we shall be able to bring all classes of fracture at the ankle joint into conformity with this understanding and by further subdivision we shall be able to group all these various types in a truly scientific manner which was never possible under the old nomenclature. Is it an eversion or an inversion type? Is there a fracture of the fibula alone? Is it high up or at the level of

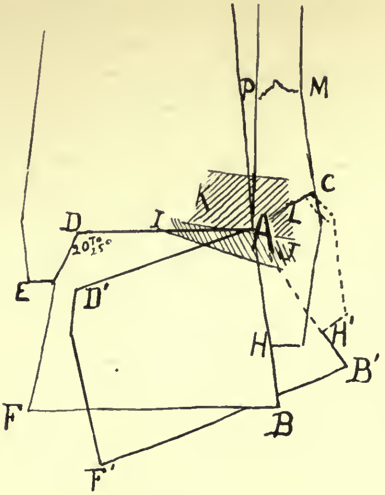

Fig. 2.

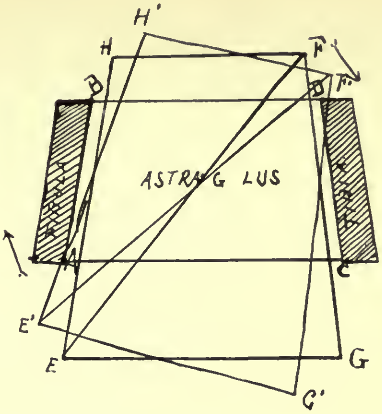

Fig. 3.

Fig. 2. This is a schematic representation of the movement to which is attributed by most surgeons the broken external malleolus and the supposedly ruptured internal lateral ligament. It is clear that if point *D* were to drop to point D^1 the external malleolus would be broken; *I. J.*, the transverse ligament would give way and often times, *K. L.*, the inferior tibiofibular ligament also. The internal lateral ligament would nearly always be ruptured. No such movement is possible as an examination of Figure 4 will clearly prove. The astragalus slides over against the external malleolus to exert pressure undoubtedly, but it cannot turn. The fibula breaks across *A. C.* and at times, as explained in the text, at *P. M.*, because subjected to three stresses at the same time.

Fig. 3. The rotation stress. This is a representation of the twisting stress or rotation stress due to the lever of rotation. The figure explains itself. Roughly speaking, a parallelogram is rotating to force its oblique distance between two rigid walls which are large enough only for one of its sides. It cannot be done and *A* and *D* will show the pressure points, and the arrows the direction of stress. Reversed it applies to inversion as well. This is the stress which so often breaks the internal malleolus in an everting foot and the external malleolus in an inverting foot, and such breaks are made possible only because of the compression which is illustrated in Figure 4.

the joint? Is there dislocation of the astragalus? Is there a broken internal malleolus alone or as a complication? Is there a rupture of the inferior tibiofibular ligament? Is there displacement of the inferior fragments? Is there an impact split of any type?

These are things which we must know when we take into consideration the individual case and these are all types which will fall readily into the subdivisions of a classification such as we suggest, the main divisions of which are eversion and inversion types of compression leverage fracture of the ankle.

In order to prove our points it is necessary that we have a clear conception of the anatomy of the ankle joint and also of the articulations of the tarsal bones. Briefly, the three bones which make the articular mortise of the ankle joint are the fibula, the tibia, and the astragalus, and we are concerned particularly with their articular surfaces.

The articular surface of the expanded lower end of the tibia is divided into two parts: its malleolar portion which articulates with the internal lateral surface of the astragalus, and the main portion which forms the weight bearing surface for the astragalus. This latter surface is regularly concave from before backward representing thirty-five to forty degrees of a very small circle and in the upright position the posterior border is on a much lower plane than the anterior.

It is slightly convex instead of concave from side to side, the slope being upward and outward toward the articulation with the fibula so that when articulated, the tibial surface receives the articular surface of the astragalus more deeply at this point of junction with the fibula. The anterior edge of the tibial articulation is convex and forms a distinct lip where it slopes upward and inward to become continuous with the anterior surface of the internal malleolus. This is a point to remember in considering the anterior splits due to impact (see Fig. 7). The posterior articular edge of the tibia forms, roughly, a horizontal S from its articulation with the fibula as it passes inward to form the posterior edge of the internal malleolus and thus also forms a distinct downward projecting lip which is a great determining factor in the posterior splits of the tibia which are so common. The external malleolus is the greatly expanded end of the fibula, the expansion beginning gradually about 2 to 2½ or even 3 inches above the tip. The area of this expansion is to the area of the fibula at its narrowest portion, roughly, as 4 is to 1 and this is an important point for us to remember as influencing the point of break of the fibula. The slope of the articular surface of the external malleolus is from before backward and inward, that is, toward the mid-line and also from above downward and outward, but the angle of outward slope especially posteriorly is very small. The slope of the articular surface of the internal malleolus is from before backward and inward (toward the mid-line) and from above downward and outward (away from the mid-line).

Measured from the line of joint surface to the tip of the external malleolus it is, roughly speaking, about twice as great a distance as it is to the tip of the internal malleolus.

Anteroposteriorly, the two malleoli are approximately the same, the internal malleolus however diminishes in depth and is notched where it runs back to become the posterior edge of the tibia. Therefore the articular surface of the external malleolus is nearly three times in area the articular surface of the internal malleolus and the fibula fits into a large depression in the outer surface of the tibia so that there is a spur of tibial bone both anterior and posterior to this articulation and both are subject to stress at times (Fig. 7).

When these two bones are joined they form a mortise broader in front than behind by fully one quarter, the external surface of the mortise being deeper than the internal, the superior surface sloping from the anterior edge downward and backward in a rough curve.

Into this mortise fits the astragalus, a wedge shaped bone, one quarter wider anteriorly than posteriorly. The anteroposterior diameter of its articular surface is roughly fully one-third more than the lateral measurement at its widest portion. It is also a wedge-shaped bone so far as its tibiofibular surfaces are concerned, from above downward; the wider part of the wedge below; the articular facets for the external malleolus and internal malleolus sloping downward and away from the center of the bone and also sloping from before backward and inward, i.e., towards the center.

There are only a few points to remember about these articular surfaces. The internal articular surface is in area not one-third of the articular surface for the external malleolus and it is only one-half the depth. Most important of all, the slope inward (i.e., away from the center) of this internal articular surface of the astragalus is an angle of fully twenty-five degrees which facilitates both from its angle of slope and its small area the escape of the internal malleolus from any breaking stress imposed upon it by eversion. It would be impossible for the internal malleolus to suffer a fracture from any such turning movement, if such movement were possible as is claimed. It would always escape fracture.

Now there are three other bones which while not entering into the formation of the ankle joint are of tremendous importance in determining an injury at this articulation: the os calcis, the scaphoid, and the cuboid. It is sufficient for our purposes to call attention to the salient points in the relation of these bones to fracture at the ankle.

The astragalus articulates with the os calcis by two articular surfaces, an anterior and a posterior; or better perhaps, a posterior and external and an anterior and internal; and these two articular surfaces are separated from each other on both bones by a recess or groove which gives origin to the interosseus astragalocalcanean ligament. On the astragalus the posterior or external articular surface is a deeply concave surface but it is concave obliquely from behind forward and outward so that when articulated with the os calcis the posterior rim of this surface forms a downward projecting spur of bone which overlaps the corresponding surface of the os calcis and is, therefore, a barrier to prevent posterior dislocation of the os calcis on the astragalus (see Figs. 8 and 9).

This articular edge is in the form of a horizontal S, the anterior limit being on a much lower plane than the posterior. This external and posterior articular surface on the os calcis is a much larger surface than the anterior or internal articulation. It is convex from behind forward and in order to fit the astragalus this surface is oblique extending from the inner side of the bone just behind the sustentaculum tali, forward, outward and downward, the slope being in two directions, forward and downward roughly on an angle of 35 degrees and outward on a plane of 20 degrees. This arrangement is such that this external or posterior articulation is much lower anteriorly than posteriorly and is lower externally than internally where the os calcis rises to form the great protuberance which is the external surface of the sustentaculum tali. Anterior displacement of the os calcis on the astragalus is therefore prevented by this downward and forward slope of the articulation. Backward displacement is prevented by the wedge of posterior bone overhanging the os calcis. External dislocation is prevented by the outward and downward slope and by the slipping over of the great sustentaculum tali to impinge on the inner side of the astragalus preventing further sliding in that direction. The anterior internal articular surface on the os calcis is comparatively small. It is on a much higher plane than the external articulation and begins on the superior surface of the sustentaculum tali; slopes forward, downward, and outward to turn upward a little at its extreme anterior surface; and therefore it articulates obliquely with the under surface of the neck of the astragalus. The astragaloid neck fits snugly into the small recess formed by these two converging slopes and under compression this point offers resistance to internal dislocation; but internal dislocation is a much more likely form of trauma at this articulation than any other. There are no buttresses of bone to impinge and prevent dislocation; and there is a distinct tendency for the os calcis to turn inward pivoting on the comparatively small internal and anterior articular surface. This movement causes the separation of the external and posterior calcaneo-astragaloid joint so often resulting in rupture of the middle fasciculus of the external lateral ligament. When this separation is sufficient to force the overhanging posterior spur of bone on the astragalus free from its tendency to lock on the os calcis, internal dislocation can occur. Internal dislocation at this articulation would be a much more common injury save for the compression that tends to keep these bones together and for the fact that this internal articulation is on a plane so much superior to that of the external articulation that while this tendency to pivot is present, nevertheless this higher anterior articulation permits a wider separation of the external articulation before dislocation can occur (see Fig. 9). The cuboid os calcis articulation viewed from below presents much the same anatomy: two surfaces which slope in opposite directions laterally to form a recess on the anterior inferior surface of the os calcis into which fits firmly a spur of bone on the inferior internal surface of the cuboid. The slant of this articulation is also from above downward and backward so that dislocation at this joint is resisted. It cannot become dislocated superiorly from the compression because of the slant of this articular surface. Inversion or eversion equally lock it against spurs of bone and the only force which would be likely to cause dislocation here would be a blow directly from above. The astragaloscaphoid articular surface is a rounded head on the astragalus which fits into a moderately deep cup on the scaphoid. Dislocation upward and inward is resisted because the inferior edge of this scaphoid cup is on a plane posterior to the superior edge. External dislocation is resisted because the scaphoid wedges against the cuboid and also against the anterior internal tip of the os calcis. Again, downward from a direct crush-ing blow would be the only likely form of dislocation; or inward, simply as a part of an internal dislocation of the os calcis on the astragalus. The meaning of this seems clear. If we take the articulated foot and apply this knowledge of the various spurs and lips of bone and the slants of the articular surfaces we shall see that under compression all the bones of the foot lock into a more or less rigid whole and that this picture is enhanced when we articulate the cuneiforms and the metatarsals. Under compression there are shoulders of resistance at almost every point, especially pronounced when we apply eversion. Under compression and inversion there is a locking to prevent dislocation but to no such degree as in eversion, and there is much more latitude of motion. Dislocation is prevented, we must remember, to a certain extent by the interosseous ligament which runs from the astragalus to the os calcis. But the main points are that all the bones of the foot under compressive stress are locked so that dislocation is unlikely; that in the position of eversion and outward twist, there is a locking to the point of absolute rigidity; that in the position of inversion there is a locking sufficient to prevent dislocation usually but with a much freer movement of all the tarsal bones; and that in direct inversion there is the tendency to separation of the external calcaneo-astragaloid joint. All these bones are joined together by ligamentous structures, the most important of which so far as ankle joint lesions are concerned are the inferior tibiofibular, the tibio-astragaloid and the internal and external lateral ligaments.

The Ligaments. The fibula and tibia are bound together at the inferior articulation by three ligaments: the anterior and posterior tibiofibular and the transverse, which is in reality a part of the latter. These are tense firm ligamentous structures capable of but little stretch and holding these bones in firm apposition. They are the only ligaments of the ankle joint which, under all conditions and positions are tense and firm; and they are tense and firm because upon their integrity rests the entire mortise of the ankle joint. If they were not tense and firm the mortise of the ankle joint would give at every little strain and a turning foot would result. The internal lateral and the external lateral ligaments are not tense and firm but are lax and if this were not so there would be restriction of the hinge movement of the astragalus on the tibiofibular mortise.

The capsular ligament is not strictly speaking a ligament at all. It is the self-lubricating mechanical contrivance for properly lubricating the joint. It is loose and at certain points it is thickened into ligamentous structure like the anterior and posterior tibio-astragaloid which, like the internal and external lateral, are only tense under certain conditions.

We know that there is no contraction and relaxation in ligamentous structure as there is in muscle and if the anterior tibio-astragaloid ligament was tense, with the foot in the position of dorsiflexion, it would be impossible for us to extend the ankle joint beyond this point. The same would apply to the posterior tibio-astragaloid ligament in plantarflexion. The fact of the matter is that these ligaments are only tense when the limit of motion has been reached; and at other times they are comparatively lax structures which do not resist normal physiological excursions of the bones until a certain position has been reached, this position being their point of greatest extension. Beyond this they are of value and hold or rupture in direct relation to the force applied. This same reasoning applies to all ligamentous structure crossing a joint surface where there is motion. They are simply additional restrictions or safeguards when the motion has swung beyond the safety point. The two forces holding joint surfaces together are: (1) the muscle tendons which are capable of extension and relaxation from the normal tonus of the sarcous elements of their muscle bellies and so capable of adaptability to a thousand different positions of the bones of the joints—automatic controls exerting exactly the correct amount of pressure and tension to maintain stability; and (2) atmospheric pressure. The ligaments are simply checks or safeguards to become efficient only as last resorts or as last lines of defence.

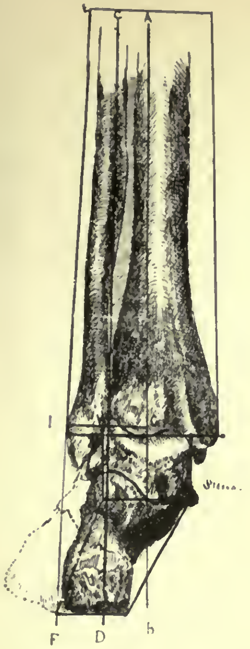

Fig. 4.

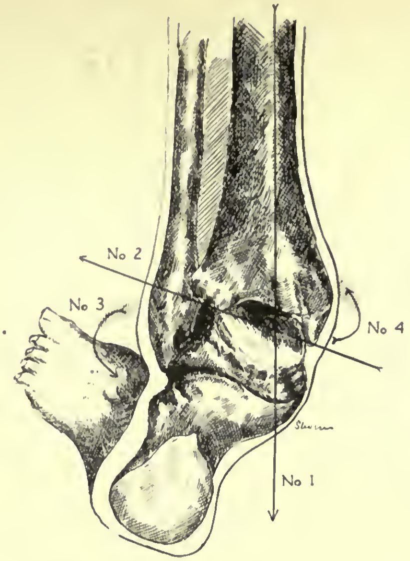

Fig. 5.

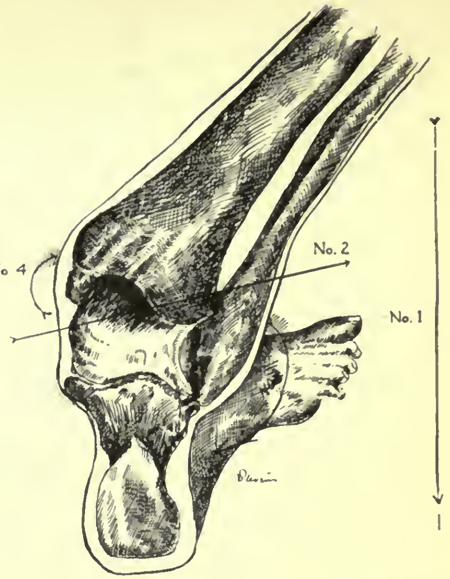

Fig. 6.

Fig. 4. The distance from the center of compression to the line of resistance in a column or strut is the lever of eccentricity. Problem: Weight of man, 150 pounds; area of column at astragalus, 1 inch by 1 inch; lever of eccentricity, 0.5 inch. *A.-B.*, center of column and also neutral axis in ordinary standing position of foot; *C.-D*, line of resistance; *G.-H.*, lever of eccentricity. In abducting represented by dotted line; *F.-E.*, line of resistance; *G.-I.*, lever of eccentricity.

$\frac{150}{1\times1}=150$ pounds of straight compression, due to static load over entire column. Additional stress due to eccentricity.

$$150\times0.5=\frac{F\times1\times1\times1}{6}$$ in which F is cortical stress.

$F=450$ pounds compression on fibula side.

$F=450$ pounds tension on tibial side.

450 pounds compression due to eccentricity plus 150 pounds straight compression equals 600 pounds compression on fibula side at astragaloid level.

450 pounds tension due to eccentricity on tibial side minus 150 pounds straight compression equals 300 pounds. Tension on tibial side of our column at the astragaloid level.

Can 600 pounds be offset by 300 pounds?

If not, the astragalus cannot turn.

The heavy outside lines show how the leg and foot bones represent a column always with an offset base to the fibula side which explains why fibula fractures are more common and why the apparently simple cases are always serious injuries. Dissemination of great compressional stress results in much injury and is not confined to the bony structure.

Fig. 5. First method in mechanics of eversion. Arrow 1 shows center of gravity internal to everting foot. Arrow 2 shows resultant of the eversion stress due to the lever of abduction. Arrow 3 shows direction of the twisting stress, responsible for long fragments and for posterior displacement of the inferior fibula fragment, due to the lever of rotation. Arrow 4 shows direction of the twisting stress expended on the internal malleolus and causing not alone its fracture, but the anterior displacement of the internal malleolus so often present in the eversion type due to the lever of rotation.

Note in both drawings, Figures 4 and 5, the relations of the tip of the fibula to the os calcis at the astragaloid os calcis articulation showing how impingement of the articular rim of the os calcis in sliding outward, may break off the external malleolus low down when the stress is mild and the victim recovers his equilibrium in time to avoid a more serious injury.

Fig. 6. Second method in mechanics of eversion fractures: Arrow 1 shows center of gravity, in this case far external to turning ankle. In reality the man is turning on his fixed astragalus. Note how a toeing out of the foot (the civilized foot) will tend to prevent the ankle from rolling over into inversion and thus saving itself. Resultant and twisting stresses are same as in preceding. Arrow 2 shows resultant of eversion. Arrow 3 shows direction of twisting stress on external malleolus due to the lever of rotation. Arrow 4 shows direction of twisting stress on internal malleolus due to the lever of rotation.

If it were not so, these ligaments would of necessity have to possess a certain contractibility which they do not possess.

That the astragalus is held in close contact with the tibiofibular articular surface by muscle tonus and not by ligamentous tension is a fact that is clearly demonstrated if all the muscular attachments are cut in a recently

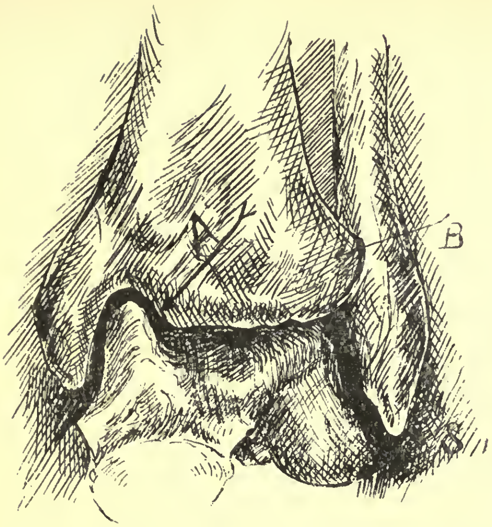

Fig. 7. Anterior view in hyperdorsiflexion. Note the shoulder of resistance of the tibia to meet a rotation outward of the astragalus in eversion and rotation (A). This explains the force which added to impact is more likely to determine the extent of the anterior splits of the tibia. Note also at B how the fibula at its articulation with the tibia is set into a depression in the tibia and therefore has a ridge or tuberosity of tibial bone in front and behind. These are both broken at times, but not often.

dead cadaver. After rigidity has set in it is quite a different story. If all the muscles of the ankle joint are cut in an operative case one will be surprised at the laxity of the tibiofibular astragaloid articulation.

There is no such laxity of ligamentous structure where bones are bound firmly together and motion is not a requisite, as in a synarthrodial joint.

This applies to the anterior and posterior tibiofibular ligaments which bind the inferior tibiofibular articulation, which while not strictly a synarthrodial joint possesses little motion. The articulation then at the ankle joint consists of the fibula and tibia bound together strongly and firmly by non-expansile and non-contractile ligaments, the anterior tibiofibula across the front and the posterior tibiofibula in exactly the same relation behind; both, firm tense bands and both aided by the tremendously strong interosseous tibiofibular ligament above.

The anterior ligament does not run from the tibia to the tip of the external malleolus. It is inserted fully an inch above the tip and here is an important point which influences the character of these lower fibula fractures.

The same applies to the posterior ligament but the transverse ligament which is in reality a portion of the posterior is inserted into the fibula closer to the tip of the external malleolus and extends backward and upward obliquely to the tibia. It is partly below the articular surface of the bone and is itself included in the articular surface of the joint which receives the astragalus. Internally we have the internal lateral ligament originating from the anterior, inferior, and posterior surfaces of the internal malleolus and inserted by its deeper fiber into the astragalus and by its superficial middle fibers into the sustentaculum tali of the os calcis.

The anterior portion is weaker but still strong and runs to the inferior calcaneo scaphoid ligament. It has no line of separation from the capsule unlike the posterior part which is tremendously strong. It must be remembered that only that portion going to the sustentaculum tali of the os calcis runs directly downward, the anterior portion running only slightly downward and forward, the posterior slightly downward and backward.

The external lateral ligament really consists of three well separated bands two of which are really parts of the capsule. The anterior runs forward and inward from the anterior border of the external malleolus to the astragalus in front of the lateral articular surface.

The posterior band is a very strong band and arises from the hollow on the inside of the tip of the external malleolus and runs inward and backward to the astragalus behind the posterior angle of the articular surface. This portion, together with the transverse, strengthens the posterior surface of the joint. Again it must be remembered that these two bands do not run downward but inward. The middle band, more superficial and not included in the capsule, runs down to a small tubercle on the outer surface of the calcaneum. It cannot be tensed by any normal movement of the ankle but it can be tensed by separation of the external calcaneo-astragaloid joint by inversion, as we have said.

So that the only ligaments which are firm and tense in all positions of the joint are the two inferior tibiofibular and the transverse and above the interosseous to keep the tibia and fibula firmly together. Even these permit of a certain amount of rotation of the fibula on the tibia at this articulation, but that is all. There is no laxness of these ligaments in any position of the foot as there is in all the others.

The muscles which surround the joint and which by tonus, aided by atmospheric pressure, keep the joint surfaces together when not weight-bearing are the tibialis anticus, the extensor longus hallucis, the extensor longus digitorum and peroneus tertius in front and they are closely related to the bones. Anteriorly they are bound down by the two divisions of the anterior annular ligament. On the posterior surface of the fibula externally are the peroneus longus and brevis. The flexor longus digitorum and the tibialis posterior play in a groove on the internal posterior surface of the tibia, while further out toward the mid-line is the groove for the flexor longus hallucis, also held in close juxtaposition to the bones by the posterior annular ligament. All these tendons are therefore in a very constricted region and all are in close juxtaposition to the ankle joint. Any damage to this structure is not only very apt to be felt by the tendons of these muscles but it is impossible for any serious injury to happen without subjecting them to more or less trauma. (See Fig. 1.)

The etiology of all these injuries of the ankle joint is practically the same. A person steps from a height like a curbing and turns his ankle. He falls from a height great or small and turns his ankle outward or inward. He slips and does the same thing. Running or jumping he turns his ankle in alighting. Or, as in the case of ball-players, he slides for a base and encounters an obstruction with his foot. If he is a heavy person it sometimes happens in the course of the ordinary walking over rough ground, but usually there is the phenomenon of impact in most of these ankle fractures.

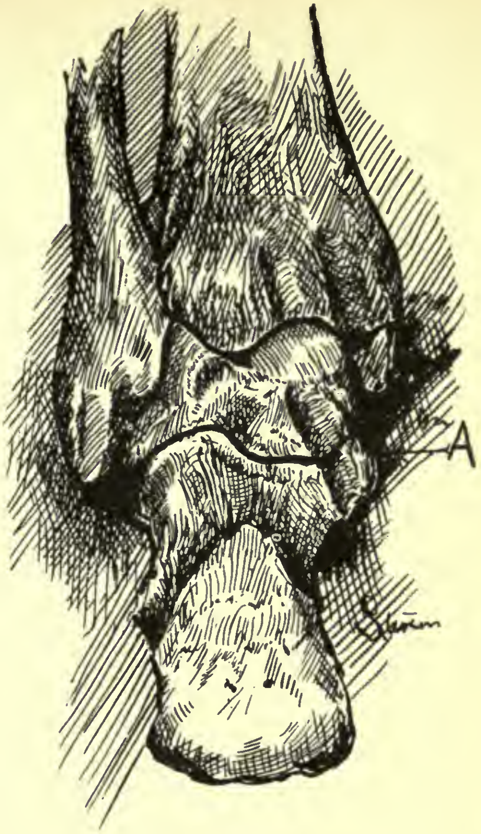

Fig. 8. Shows the exterior or posterior calcaneo-astragaloid joint in straight or everted position of foot. Note the horizontal "S" shaped joint line "A" and the downward projecting lip of the astragalus causing a wedging of these bones especially pronounced in eversion. Note also how there are two lips on the posterior surface of the tibia to meet resistance of a twisting astragalus in plantarflexion. Note the tendon grooves on tibia, fibula, astragalus and os calcis and visualize whether or not they would suffer in any injury to the ankle joint. Note the notch in the surface of the external malleolus which explains why when the os calcis articular lip is large and slips outward at the astragalo-calcaneal joint, the fibula tip sometimes breaks at this level, i.e., half way.

Now, the medical profession as a whole is united on certain of the fundamental mechanical features of the production of these fractures while differing on minor points. Some believe like Stimson, Bonnet, Ross and Corless, Roberts and Kelley, and Tillaux, that the internal lateral ligament tears or the internal malleolus breaks first, and that this is followed by a fracture of the fibula.

Meissoneuve, Speed, Ashurst, and Murphy believe that the fibula breaks first in abduction and eversion and that coincidentally the internal lateral ligament tears or pulls

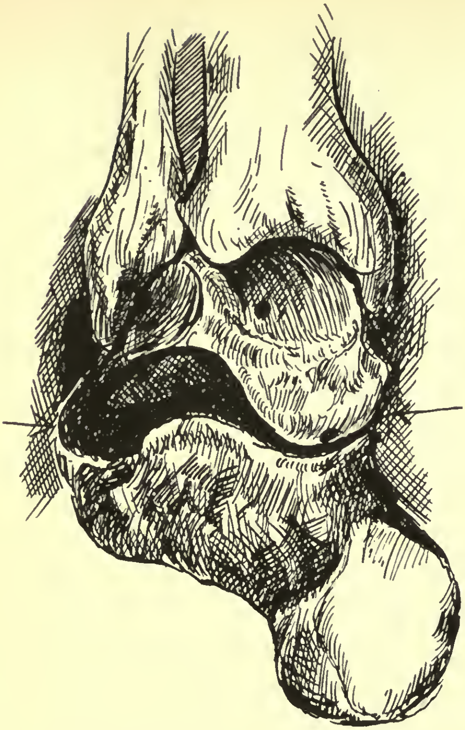

Fig. 9. This shows how in an inverting foot, there is separation at the external calcaneo-astragaloid joint. It falls short of dislocation because the internal calcaneo-astragaloid joint which is not seen in this view is at a higher level. This explains why the middle fasciculus of the external lateral ligament is so often injured in these inverting ankle injuries. Nothing of this kind can happen in the everting foot, but instead the greater the eversion the tighter these bones are locked, except for a slight lateral slip in a straight eversion.

off the internal malleolus. So that there is agreement between these two groups that there must be a turning outward of the astragalus. Because if the internal malleolus breaks before the fibula through the pull of the internal lateral ligament, as they claim; or the internal ligament is torn; then this must be accomplished by a dropping down of the inner edge of the astragalus in order to put these two points in jeopardy.

And if the fibula has broken first, and the internal malleolus is broken by the pull of the internal lateral ligament, or the internal lateral ligament is torn, as the other group claim; then this also must be the result of the inner edge of the astragalus turning downward at the time of the break; because if caused by the astragalus slipping outward, there would be the outwardly dislocated astragalus always; and this is not true. Many times the astragalus is not dislocated outward and nevertheless the internal malleolus is broken. This is a statement of fact and can admit of no controversy. Now the third class—and this class is composed of some of each of the other two classes because none of them contend that this is anything but an accompanying stress in connection with other stresses—believe that there is a rotation outward of the joint pivoted on the center of the astragalus. This was Meissoneuve's idea and he made some experiments which seemed to confirm it.

Honigschmeidt made many experiments, as did Bonnet, which seemed to prove that by this external rotation it was possible to break the external malleolus, but both claimed that the internal lateral ligament was broken at times.

Ashurst says that in his experiments he got a fracture of the internal malleolus oftener than a torn internal lateral ligament.

All of these experiments incite in us a certain amount of envy at the wealth of material wasted, but most of them can be dismissed with the statement that in none of the experiments reported was there any attempt at anything approaching a reproduction of the actual conditions of stress. All of these experiments proved that under conditions which never existed in the actual production of the lesion, all sorts of breaks could be produced. Now, in order to demolish the theories of the two first groups, it is only necessary to prove that the astragalus does not turn outward, and in order to demolish, partly at least, the contention of the third group, it is only necessary to prove that the internal lateral ligament does not tear except as the result of an outwardly dislocated astragalus.

This is quite a problem since it controverts the opinion of pretty much the entire surgical profession, except the few who believe that as the result of rotation of the astragalus the fibula breaks and the break is followed or accompanied by a broken internal malleolus.

Figure 2 shows us exactly the conditions claimed for the astragalus by the first two groups in the production of this injury by abduction. The same argument holds good for adduction fractures because here there is a universality of opinion, the external malleolus is broken first by the pull of the external lateral ligament and with an intact internal malleolus the external lateral ligament is stressed only by a separation of the astragalus at its superior articular surface.

No one cares what a man's individual opinion may be if he cannot prove it. If he can, it will stand by itself even against a combination. For the problem is simple. We must prove that the astragalus can have no such turning motion as is represented by Figure 2.

The abductionists of both groups have attempted to show that by the turning outward which we have represented schematically in Figure 2, the astragalus is trying to tip the fibula malleolus AHC outward until it occupies the position of AH′C. It is clear that the astragalus can only do so by breaking the fibula in the line AC, or if the ligaments are loose or break in the line higher up at or near PM; because even if the fibula bends and breaks at its point of greatest weakness, PM, we shall still not have a tremendously dislocated foot so long as the transverse ligament represented by IJ and the anterior and posterior inferior tibiofibula represented by KL are intact. This is evident if we glance at the diagram.

The abductionists claim that the first movement is the turning of the astragalus in the attempt to bring the line AD into the line AD′ and this movement ruptures or tears the internal lateral ligament. Let us prove this impossible.

Compression is not a mere word. It means something. It is an interpretation of the type of injury. It shows why there is no turning motion possible to the astragalus itself.

Let us consider the fibula and tibia, the astragalus and the os calcis, as a column. It is just that, in the main, when we consider the possibilities as regards compressional stress. The fact that there are two bones in the leg joined together by more or less movable joints is only important to us because that arrangement diminishes or minimizes the stresses to which the ankle joint is always subjected. And the same may be said of the joints between the astragalus and os calcis. Nature is a great architect, and it is possible that by investigating we should find that this arrangement was exactly the best sort of arrangement possible in order to take up the stresses and strains to which the human animal is subjected at this particular part of his anatomy. But it must not be forgotten that certain developmental changes have taken place in man, and that now he goes on two legs where once he went on four. Stresses and strains have changed, and while structure has also changed to meet new conditions, they may not be wholly competent under these newer conditions. At any rate, for our purposes it is sufficient to consider these various bones as a column, subjected to compressive strain.

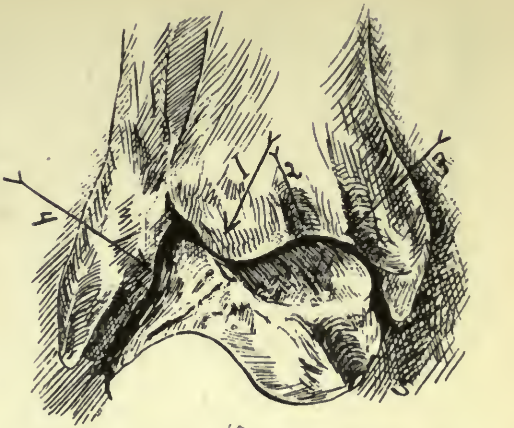

Fig. 10. Posterior view showing the tibial points of pressure from a twisting the astragalus when the foot is plantarflexed. The two arrows in the middle show that both in eversion and inversion with rotation this would act as a point of resistance to help in the production of a posterior split of the tibia. In eversion and rotation the force would be expended along arrow 1, while in inversion and rotation, it would be in the direction of arrow 2. In addition of course in eversion and rotation would be the stress against the internal malleolus at the point marked by arrow 3, and in inversion and rotation, the point marked by arrow 4, the force marked by arrow 4 acting from behind, forward and out against the fibula and so accounting for the broken external malleolus in the inversion type.

If you will glance at Figure 4, you will see that these bones drawn from behind constitute a column varying in area at different points, that the area of our column at the level of the astragalus or os calcis is much less than the area of this column at the level of the malleoli, and we shall find that the base of our column as represented by the lower surface of the os calcis is considerably pushed over to the fibula side. In other words, you walk on the fibula side of your foot.

Now, the weight of a man of 150 lbs. as he naturally walks, is thrown entirely upon the advancing foot.

Let us call the area of our column at the level of the astragalus as, roughly, 1 by 1 inch, and by the use of a simple mathematical formula which we used in our discussion of Colles's fracture (Ann. Surg., 1920) it is possible within limits to determine the compressive stress. Let A represent the length and B the breadth of any section of our column, at any level.

$$\frac{\text{Load}}{A \times B} = \text{Compressive stress in pounds per square inch.}$$

$$\frac{150}{1 \times 1} = 150 \text{ pounds of compression.}$$

So that the compressive stress upon our section at the astragaloid level would be 150 lbs. per square inch and this compressive stress is the same over the entire area of the astragalus. But this is not all. The center of compression of our column is the center of the column, the neutral axis. But because the base is offset, in the ordinary standing position the line of resistance through the base is fully 0.5 of an inch away from the center of compression and when the os calcis abducts under force this line of resistance is even further removed so that it may even fall outside the fibular surface of the column.

This last-mentioned condition in the face of stress would mean infinity, it could not be measured.

But let us assume the problem as before with an *offset* of 0.5 of an inch. The *offset* is called the lever of eccentricity.

$$\text{Load} \times \text{eccentricity} = \frac{F \times A \times B2}{6}, \text{ in which}$$

F is the cortical stress in pounds per square inch.

$$150 \times 0.5 = \frac{F \times 1 \times 1 \times 1}{6}$$

$F = 450$ pounds compression on fibula side;
$F = 450$ pounds tension on tibial side.

On the fibula side, we must add the 150 pounds of straight compression and deduct it from the tibial side.

Stress in Compression. Fibula side of our column at the astragalus—600 pounds per square inch.

Stress in Tension. Tibial side at the astragalus—300 pounds per square inch.

Now this is only a stress of common static load in walking. It is no wonder that the bones are specially arranged to take up some of this stress. This is no light weight.

Can the astragalus turn? Can 600 pounds be offset by 300? If it cannot, then we have demonstrated our point. This disposes of the first two groups and their contention. With the third we shall deal later when we take up the consideration of the internal malleolar break. We disagree with them only when they assert that there is a break in the internal lateral ligament.

Let us now consider this same column of compression as it affects the fibular break.

We have the same column as before represented in Figure 4 and if we apply what we have learned already and call our section at the malleolar level as 2 by 1 inch, we shall find that here the static load as straight compression would be 75 pounds on both the fibula and the tibia. If we reckon the eccentricity as before—in an everting foot it is more than ½ inch—we shall find that the cortical stress developed over the fibula is 300 pounds per square inch as against a tibial stress in tension of 150 pounds.

It can also be clearly demonstrated that there is a tremendous lever of eccentricity formed in a posterior direction with a plantar-flexed foot undergoing stress, especially when the heel catches on the edge of a depression. This accounts for a great number of posterior splits of the tibia.

Now, add impact, which is many, many times greater than static load (see Merriman, Mechanics of Motion) and we shall begin to visualize what may happen when a man weighing 150 pounds steps off a 4-inch curbing and turns his ankle outward. This explains those cases, rare, fortunately, where, in

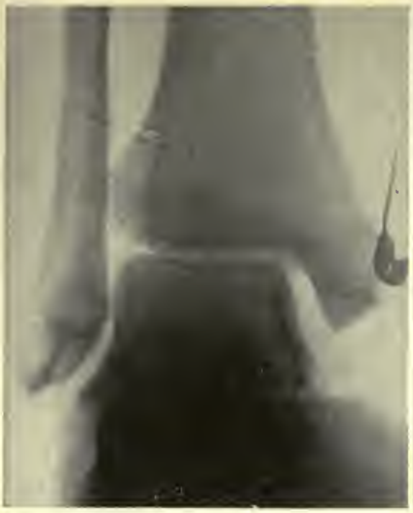

Fig. 11.

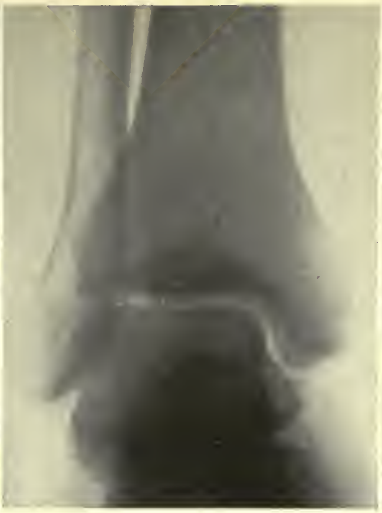

Fig. 12.

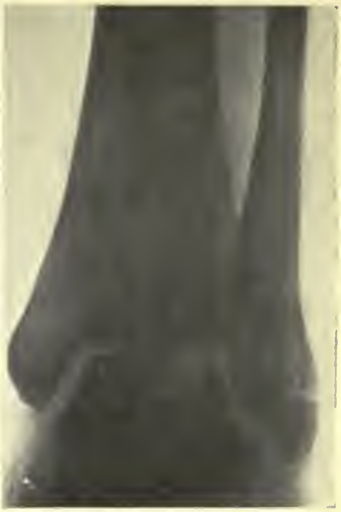

Fig. 13.

Fig. 11. Roentgenogram of an eversion injury. Practically it is a Pott's fracture without the fracture. The inferior tibiofibular ligaments are ruptured. There is, therefore, destruction of the mortise and here there is some outward dislocation. Only case of this type in our series. Very rare, 0.4 per cent of our series, but 12.5 per cent showed the feature of ruptured inferior tibiofibular ligaments in association with other types. This represents only those which showed this feature clearly in the roentgenogram plate.

Fig. 12. Type 1.—Simplest type of eversion injury. Periosteal tear of fasciculus of internal lateral ligament which runs down from the tip of the internal malleolus to the sustentaculum tali (0.8 per cent of our series). This is a much rarer injury than the periosteal tear of the external lateral ligament from inversion which is commonly due to the easier separation of the external calcaneo-astragaloid joint.

Fig. 13. Type 2.—Eversion fracture. Mild type of leverage fracture. Note large expansion of calcaneo-astragaloid joint. The cause of this injury is a stress of low intensity and the sliding over of the expansion of the os calcis at the astragaloid os calcis joint, striking the tip of the fibula. If the inferior tibiofibular ligament is not ruptured, it is of small importance and weight bearing may be permitted with care early (2.81 per cent of our series).

eversion the fibula is broken in compression and the whole lower end of the tibia is broken free, the break of the tibia running transversely, but usually slightly upward across the tibia toward the fibula. This would happen oftener save for the fact that the external malleolus, under this tremendous compression, is subjected to a cross-breaking stress by either the outside of the astragalus forced against it, or occasionally by the articular edge of the os calcis. The blow does not have to be great. The fibula is under compression and it breaks and sometimes you will find a fragmentation of the external malleolus exactly as happens in granite when subjected to compressional stress.

Even if the fibula breaks, this tremendous compressional force must still be disseminated. The force of the impact in these cases is the added compressional force of a 75-pound hammer dropping through the distance which the man falls, and this multiplies the stress infinitely. This force is only distributed at the expense of all the ankle tissues, bony and soft. The dynamics of compression here accounts for the seriousness of these ankle injuries. The fact that compression is greatest always on the fibular side accounts for the preponderance of these fibular breaks.

In inversion, it is clear that while under compression, the lever of eccentricity is not in any way so pronounced and therefore the stresses in compression are by no means so accentuated with an inverting foot as with an everting one.

We may use the same method to determine the stress in compression suffered by both the astragalus and os calcis. It is evident that if our column were a rigid one, crush fractures of both of these bones would probably outnumber the ankle injuries, but as both these bones are more adapted to resist stress, the fractures are at the weaker points of our column, or at those points where additional stress has been induced.

Under compression, a column or a strut is subject to leverage breaking stresses, but with certain modification. A much smaller stress will serve to fracture. It is a well-known fact that during a test of a boiler under hydrostatic pressure, every engineer is instructed to be especially careful not to subject the boiler to any sudden local stress (as a sudden blow with a hammer) because plates are very apt to rupture, and this rupture may be far removed from the local source of the blow struck. The same thing applies to an iron or steel support which, undergoing compressive stress, is struck a sudden blow. Rupture is produced by a comparatively slight stress under these conditions.

Now, let us consider the leverages of eversion, or the mechanics of eversion as distinguished from the compressive stress.

The fracture is the result of compression plus leverage in two directions, and this applies whether the fracture is of the eversion or the inversion type.

The terminology is not clear. One man uses abduction to mean the turning outward of the whole foot, and eversion to mean a rotation outward of the forward part of the foot; while another uses both terms to mean a turning outward of the whole foot, and rotation to mean the twist of the forward part of the foot either outward or inward.

In this article the terms abduction and eversion are synonymous: abduct—to withdraw from the body axis; evert—to turn out. Therefore the entire foot is withdrawn or turned out. The term rotation is used to mean the twisting of the foot on the astragalus as a pivot, that is, the forward part *only* is turned outward. These two stresses are simultaneous in the actual conditions.

A pure abduction or eversion without external rotation is a rarity.

A pure adduction or inversion without internal rotation is an impossibility.

There are two distinct levers formed which we shall call (1) the lever of abduction or eversion, and (2) the lever of rotation.

THE MECHANICS OF ABDUCTION

There are two distinct mechanical leverage entities involved in these eversion fractures and while the results in both are for all practical purposes the same, there is a certain amount of difference in the accentuation of stresses developed in the second variety as compared to the first; the first, nevertheless, producing by far the greater number of injuries. The first, as one may see by glancing at Figure 5, is produced while the center of gravity of the entire body remains internal to the foot, potentially turning outward on the astragalus. The second is produced, as may be clearly seen by a glance at Figure 6, while the center of gravity is external to the foot. It is clear that there is a difference here represented by a difference of leverage. In the first method of production, the foot is the turning or moving portion, the lever is a short lever—a pinch lever—the power applied below, the fulcrum is the inferior tibiofibular ligaments. The weight to be lifted is the weight of the entire man, which must be moved over in order to release the foot from its position of strain, but the strength of the lever is only the tensile strength of the external malleolus which is also under compression almost or even quite to its elastic limit, as we have shown. The bending and breaking moments of the lever are the same and where the inferior tibiofibular ligaments hold the fibula breaks at the level of the joint. There are exceptions, but they are few. In the second method of production, Figure 6, the foot is the fixed portion, the man's weight being the power as he falls outward, the fulcrum of the lever being the point of junction of the fibula and tibia held firmly by the inferior tibiofibular ligaments and the weight to be lifted or moved over is not only the weight of the foot, but it is the weight of a foot fixed under compression plus the resistance of the topographical obstruction which is preventing it from turning inward to relieve the stress.

Here is a long lever with the fulcrum practically the same as before but higher up, and the weight below. Now, as we have shown and as can be easily determined by a brief study of the mechanics of motion as applied to levers, a short and rigid lever—a pinch lever—will break at the fulcrum; while a long and weak lever whose bending and breaking

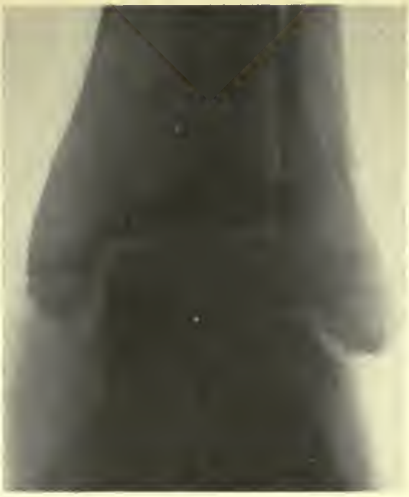

Fig. 14.

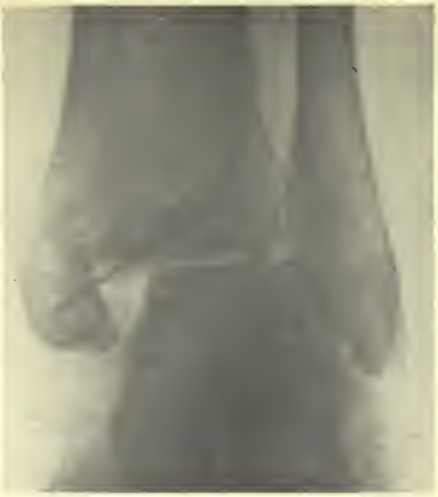

Fig. 15.

Fig. 14 (at left). Type 3.—Eversion fracture. Sub. Div. A. Only the internal malleolus has suffered. The internal malleolus is apt to be displaced anteriorly if due to eversion, and this is one of the diagnostic points of eversion. This half way fracture of the internal malleolus is not uncommon, due to the twist of the astragalus. Many times such a lesion occurs when the compression feature of these injuries (weight) is not present, but not always. This type A and B represent 6 per cent of our series where it was clearly eversion.

Fig. 15. Type 3.—Eversion fracture. Sub. Div. B. Same mechanics as before but more apt to result when compression is a feature. The external malleolus has resisted the stresses, but the inferior tibiofibular ligaments have ruptured, thus permitting dislocation. The internal lateral ligament is intact. Notice how impossible it would be to apply the ordinary definition of a Pott's or a Dupuytren's to this injury. Nevertheless the mechanics are the same and practically the pathology is the same. What difference would an additional broken fibula make?

movements are not the same will tend to break between the power and the fulcrum but nearer the fulcrum in exact ratio to the nearness of the breaking and bending moment.

The fibula in the living body has a certain amount of resilience, but it is not like green timber and it is comparatively rigid so that it will break frequently at the fulcrum. It would do this even more often except for the anatomical fact that it is very much weaker at a point 2.5 to 3 inches above the tip. Therefore, occasionally, especially by this second method of production, the fibula breaks high up.

Under compression the astragalus can not turn but it is closely applied to the side of the fibula and is applying pressure.

It is possible that sometimes the os calcis, whose incursions are much greater, slides out, partly dislocates, and finds a point of contact on the end of the external malleolus. By looking at the articulated skeletal bones, especially those produced by the second method, it will be clearly seen that such a possibility exists. In either case there is clearly a stress of intensity and in the first class (a short unbending lever) the tendency would be to break at the fulcrum exactly. Under compression it would require a very slight force indeed and the fracture might even be fragmented especially where the compressive feature was severe enough to reach anywhere near the elastic limit of the breaking bone, because in the terminology of the mechanical engineer, bone is cold short and is therefore subject to fracture from a small force exerted as a transverse breaking stress or as impact.

But you say that all these fractures at the level of the joint, numerically greater than the classical type, as shown by our table, are not Pott's, especially those produced by this first mechanics of ours, where the line of gravity is internal to the ankle undergoing stress and where the leverage is not the same as in the second method of production which is more likely to produce the high fracture of the fibula. The fracture is not high on the fibula and therefore is not a Pott's fracture.

Another phase of this mechanics applies equally to both methods, and makes it probable that while the second method produces more cases of high fracture of the classical type, we are by no means correct in assuming that it produces all cases or that the first method does not often produce fractures.

If you will fashion two pieces of wood as the bones are shaped, or approximating them, and bind these two pieces together or fasten them immovably at the points corresponding to the inferior tibiofibular articulation and apply force in the direction indicated by the first method, i.e., outwardly against the external malleolus, you will find that you will get a fracture at the level of the joint.

Now, if you will make the junction with a rubber band attached very firmly allowing only a very little play, you will find, provided your artificial fibula is about the same strength throughout its entire length, that occasionally you will get a break higher up; not often, but occasionally. If you model your artificial fibula so that at a level of 2.5 to 3 inches above the joint its area is to the area below as the area of the normal fibula above is to the area of the external malleolus, that is, roughly as 1 is to 4, and allow for a little elastic motion at the artificial tibiofibular joint, you will many times get a fracture 2.5 to 3 inches above. So that the explanation seems fairly clear. Four times out of five in this first method of production you will get a fracture of the fibula in this kind of injury at the level of the ligamentous insertion. If the ligaments hold firmly the break will tend to approximate the transverse. If they give at the moment of fracture you will be apt to get a fracture running more or less up the outer surface and this is apt to be helped somewhat because this surface is the compression side of the slightly bending bone. The split upward is more often posterior and external and this is the result of rotation, as shown schematically in Figure 3.

If, however, the stress is great and the impact severe and sudden, the ligaments may rupture or give enough to render useless the fulcrum of our lever.

In some cases there may be normally enough play in these ligaments to vitiate the fulcrum at this point. Instantly the fulcrum changes to a point higher up to the lower surface of a ligamentous structure infinitely stronger than the inferior tibiofibular ligaments below, the interosseus membrane, and the fibula breaks close to this point. If the fibula were of the same size throughout, it would break exactly at the point of fulcrum. But as 2.5 to 3 inches above the tip is the weakest point of the lever and in these cases of ruptured or lax inferior tibiofibular ligament the weakest point is near the fulcrum of the new lever; the break is at that point. So that probably these high fractures of the fibula are occasionally due to the first mechanical entity as well as to the second.

Most authors, writing upon this subject, select for purposes of illustration the cases which conform closely to the classical types, rejecting many of the apparently minor cases in order to prove their points, when they should really choose all cases as they come. Glance at our table of 249 cases and you will see that, excluding the periosteal tears which should be disregarded because they prove nothing, and the cases where the fibula was not broken at all; we have out of 190 cases, 139 in which the fibula was broken at the joint level. The vast majority of fractures showed a split which ran up the external or posterior surface for a varying distance but were, nevertheless, clearly at the ankle joint level at some part of the split.

Now, if we apply what we have said about the first method of production to the second method, we shall see that with the line of gravity outside the foot undergoing trauma, we have practically the same mechanics except that here the whole weight is on the foot under stress and the foot does not turn outward, as it is firmly fixed to the ground under compression; and the man's body is thrown forward and sideways (outwardly) instead, thus increasing the distance of his line of gravity outside the foot. He can not

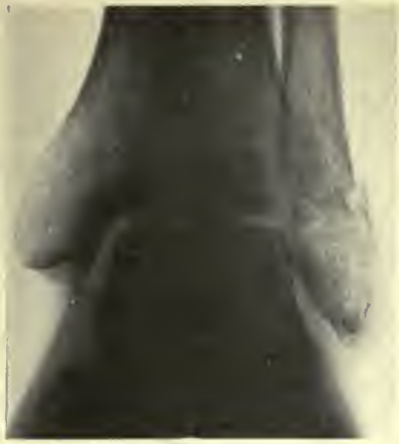

Fig. 16.

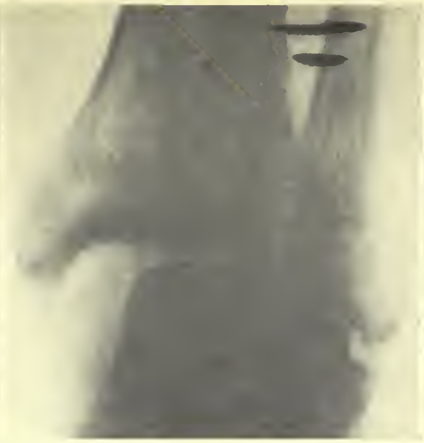

Fig. 17.

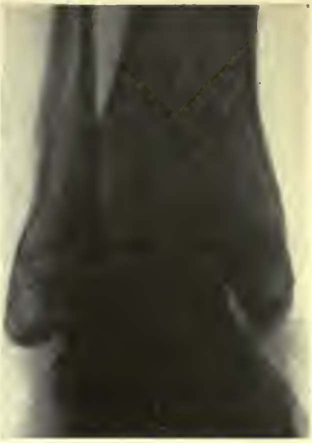

Fig. 18.

Fig. 16. Type 4.—Eversion fracture. Sub. Div. A. A leverage fracture. Break of the fibula clearly at joint level. Some displacement outward of lower fibula fragment. This is the most common type. No break of internal lateral ligament. No fracture of the internal malleolus (42.1 per cent of our series).

Fig. 17. Type 4.—Eversion fracture. Sub. Div. A. Great outward displacement. The internal lateral ligament may or may not be ruptured in this type, but if so, is usually not entirely ruptured, but torn. The tearing is directly dependent on the degree of the external displacement, and is rarely tremendous, even with great displacement. The fracture of the external malleolus is clearly at the joint level, but runs up posteriorly (42.1 per cent of our series).

Fig. 18. Type 4.—Eversion. Sub. Div. B. Same mechanics, but fracture of fibula is high up. In this case the location of the fracture is only a short distance above the joint level, but it is often higher (4.8 per cent of our series).

lift his foot, because of the compression and the topography of the ground. He falls outward, involuntarily twisting himself as he does so. The fibula breaks, the internal malleolus may or may not break, but literally the tibia in this manœuver becomes dislocated inward on the fixed astragalus instead of, as in the first case, the astragalus becoming dislocated outward on the fixed tibia.

This latter type is, therefore, more apt to be serious, accompanied by great dislocation outward of the astragalus. Again, there is no internal lateral ligament tear in these eversion fractures up to the time of dislocation because there is no more turning motion of the astragalus possible in this manœuver than in the first method.

The majority of the milder types of injury are produced by the first method, but since the results are identical and the stress the same save in intensity, it is a distinction without a difference and if one is a Pott's fracture, so is the other, serious or mild.

Let us consider the second leverage which occurs at the same moment as the stress outward on the outer malleolus, the leverage of rotation.

The third group of writers contend that these fractures are in the main due to rotation of the foot. If they would let it go at that there would be reason in their contention, since it is certain that next to compression, rotation is the most important movement which not only aids in breaking the fibula, but is also always responsible for the broken internal malleolus in eversion fractures and for the broken external malleolus in inversion fractures. It is also responsible for the broken inferior tibiofibular ligaments, especially when the ligaments are broken without fracture of the external malleolus. But most of this group go further and say that the internal malleolus is first pulled off by the strain of the internal lateral ligament, or the internal lateral ligament is broken. This internal lateral ligament seems to be an ever-present obsession. It is absurd that an entire malleolus could be torn off by a ligament.

Is there no better explanation? If we turn to Figure 3, we shall find the explanation. We know that the distance from the astragalus forward to the toes is much greater than the distance from the same point to the posterior end of the os calcis in almost the proportion of 4 to 1, and that the whole foot, partly everted and under extreme pressure is converted into a lever. The long arm of the lever is in front of the astragalus, therefore serves to twist the anterior part of the astragalus outward and backward; while the posterior part swings the other way inward and forward to impinge against the internal malleolus. The pivot is the middle of the astragalus. That is, E F is swinging over to E′F′. In other words, if we look at the drawing, we shall see that we are trying to force the diagonal of what is practically a parallelogram between two points which are rigidly made to contain only one side of that parallelogram. It is obvious that it cannot be done. The diagonal of such a structure is greater than any one side.

This is the lever of rotation. Now, this is a horizontal lever made up of all the bones of the foot and it may be called a lever of the first class if we choose to consider the external malleolus as the fulcrum and its point of contact on the internal malleolus as the point of application of the weight. It could equally as well be called a lever of the second class if we take the internal malleolus as its fulcrum and the external malleolus as the weight. Practically it amounts to the same thing. The distance between the fulcrum and weight is only the diagonal distance of the astragalus; and the power is applied far forward on the foot which is the long arm of the lever.

If the foot were in dorsiflexion, and the side strain severe and rapid without the weight of the man (the compression) in evidence, the astragalus might drop internally or be forced down sufficiently to clear the internal malleolus before the twisting motion due to this leverage of rotation came; and in certain fractures of the ankle joint where the internal malleolus is broken at the tip or almost at the tip, this is probably exactly what has happened. We have seen several ankles which had sustained injuries while the weight of the man was not on the foot. But if the twisting motion due to rotation occurs at the same time as the other stress, and the compression feature is in evidence; the inner surface of the astragalus is twisted around and meets a point of resistance against the internal malleolus posteriorly at the same instant that the external malleolus is subjected to the resultant of the two forces operating against that bone to force it outward and backward. The astragalus is thus caught at two points, the external malleolus externally at "A," the force here being outward and backward; and internally against the internal malleolus at "D," the force here being inward and forward. So far as the internal malleolus is concerned, if the foot is in extreme dorsiflexion, the anterior portion of the internal malleolus is more likely to suffer. If the foot is plantarflexed, the internal malleolus is apt to receive a stress involving a larger portion of the internal surface of the tibia, the point of contact being far back posteriorly; and the entire malleolus is apt to be torn away and even a fairly large portion of the inner side of the tibia.

But whether in plantarflexion or dorsiflexion, with the compression stress in evidence, it is extremely likely to be involved and as the stress is much greater where the line of gravity is outside the foot, that is, where the man is turning on his fixed ankle as shown in Figure 6, there is much more likelihood of its being involved than in the first method.

This lever of rotation is a short lever, a pinch lever, but in our case the lever is stronger than either the fulcrum or the weight to be overcome, because the fulcrum is only as strong as the tensile strength of the external malleolus, and while the weight to be lifted is still the man's entire weight, yet practically this is also limited to the tensile strength of the internal malleolus.

Which one will break?

In eversion the external malleolus already has imposed upon it by other stresses and especially the compressional, a greater stress than the internal. If for no other reason it would break oftener, but one or both will break because both are weaker than the lever and if their strength is equalized under all the conditions, they will both break, but if both break, they will break simultaneously, *because a lever is destroyed the instant any one of its components break.*

Here, then, we claim to have demolished the contention of the third group in so far as

Fig. 19.

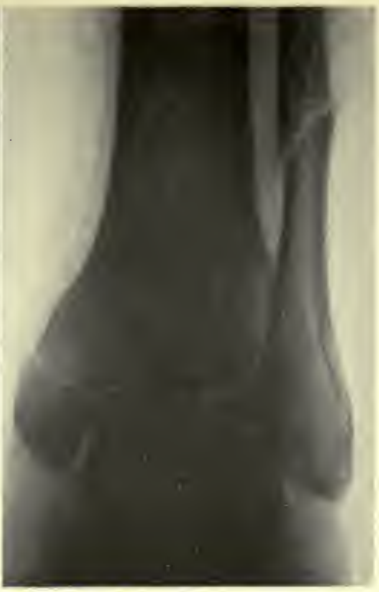

Fig. 20.

Fig. 19 (at left). Type 5.—Eversion. Sub. Div. A. External malleolus broken clearly at the joint level. Internal malleolus also broken. No rupture of internal lateral ligament occurs in these cases. Dislocation of foot is outward and backward. Internal malleolus is broken at joint level oftenest, but a larger portion may be broken from the tibia. Mechanics as given in text. The rotation of the astragalus broke the internal malleolus simultaneously with the external malleolus (13.6 per cent of our series).

Fig. 20. Type 5.—Eversion. Sub. Div. B. Same mechanics as A, but because of undue mobility at inferior tibiofibular junction, allowing more play or because of the stresses by the second method of production, and decrease in size of fibula above, the bone breaks high up. Percentage of broken internal malleoli is greater in these high breaks, because the stresses are not disseminated as quickly as in the Type 4 cases, and are greater. External dislocation is apt not to be so pronounced, while the posterior dislocation is apt to be more pronounced. Internal lateral ligament is not broken. A classical Pott's (6.4 per cent of our series only).

the internal lateral ligament is concerned, because if the astragalus is wedged against the internal malleolus from behind forward, it is certain that no portion of the internal lateral ligament can be stressed or torn until one of the malleoli breaks because, between the two fixed malleoli, the astragalus cannot rotate.

If the internal malleolus breaks, the ligament is free and can suffer no harm. If the external malleolus breaks or the inferior tibiofibular ligament breaks, the internal lateral ligament can only be injured as the result of the subsequently dislocating foot.

This, then, is the mechanics of the broken internal malleolus and it applies equally to both methods of production. The internal lateral ligament has nothing whatever to do with this fracture. It also explains the reason why the broken internal malleolus, when produced by eversion, is displaced anteriorly in a great number of cases. We submit this point as diagnostic in those cases of inversion or eversion in which the history of the accident is unreliable.

Out of 81 cases, 36 showed clearly this anterior displacement of the internal malleolar fragment and many of these 81 cases should be excluded either because they were inversion fractures or because there was no separation at all.

It is an axiom that if the internal malleolus is broken, the internal ligament is not injured except as the break forces it from its attachment to the tibia and thus disturbs the continuity of the whole; but the internal ligament is still attached to the malleolus and the intact ligament is what drags the internal malleolus outward with the dislocated foot. This also accounts for those cases in which the fibula is broken clearly at the joint surface as the result of two leverages plus compression, and the split runs up the shaft for from 1 to 2 inches. This is the mechanics of a partial torsion.

Now comes dislocation of the astragalus, but not always, because there is in many cases dissemination of the force producing the injury. In 62 cases this dislocation occurred. It is always outward and somewhat backward. If the internal malleolus has escaped, it is at this point that a tearing of the internal lateral ligament occurs because of the dislocation of the foot; and it is also at this point in dislocation that injury occurs to the tibio-astragaloid ligaments, sometimes evidenced by a slight periosteal tearing at the point of origin on the tibia. The internal lateral is, however, rarely ruptured in its entirety but where dislocation has occurred, and is great, it is many times injured; but even where dislocation is great, especially if external, the injury is in the vast majority of cases slight—a tearing which is incomplete and which, with a properly reduced astragalus, is a matter of secondary importance. With posterior dislocation, especially when great, there is more apt to be involvement of this ligament, especially of the posterior portions; but up to the moment of dislocation great injury does not occur and if the internal malleolus is broken, injury to the ligament is impossible.

We believe much of the possibility of this accident to be due to the tendency of civilized man to walk with his toes turned outward instead of, as the savage walks, with his feet slightly inward. If he sustained a stress of this kind with his feet slightly toed in, the natural tendency would be to roll his foot inward at the astragalocalcaneal and astragaloscaphoid joints because the pressure would then be on the outer side of his foot, anterior to these joints. Unfortunately, he has been trained to walk with toes turned out and when the strain comes in this position, he gives at the knee and literally has to squat upon his ankle. This does not release the pressure where the line of gravity is still inside of his ankle and instead of tending also to twist his ankle inward, as it would do if his foot were toed in, it brings an additional stress to bear by tending to twist the toes outward still further.

In the other position, if the foot is planted firmly, and the man's body is thrown quickly to the same side, the other leg lifted from the ground, the center of gravity is changed far to the outside of the ankle.

Again, had his foot like the savage foot been toed inward instead of outward, the pressure would have tended to roll the heel inward; because the whole weight would be on a small rounded surface—the under surface of the tuberosity of the os calcis—which would tend to roll under weight in spite of the compression and in most cases would succeed. It would be interesting if our contention is true, to know something about the frequency of these compression fractures of the ankle in the savage races.

This disposes of all the groups and their various claims except those few of the third group who do not believe that the internal lateral ligament can be injured save by dislocation of the foot, and believe that these ankle breaks are due to the lever of rotation alone. With these we have no argument save to point out that it is hardly logical to attribute the injury to one force when it is clear that there are two other stresses of equal or much greater intensity.

INVERSION TYPE

So far, in the main, we have dealt with the eversion type of fractures at the ankle joint, numerically much greater than the inversion type; and called by some, reverse or inversion Pott's.

Why is it that there are so few inversion fractures in comparison to the eversion? It is certain that for every man who turns his foot outward there are ten who turn it inward? As a matter of fact, there are probably many more injuries due to inversion than to eversion, but the pathology is that of an ankle

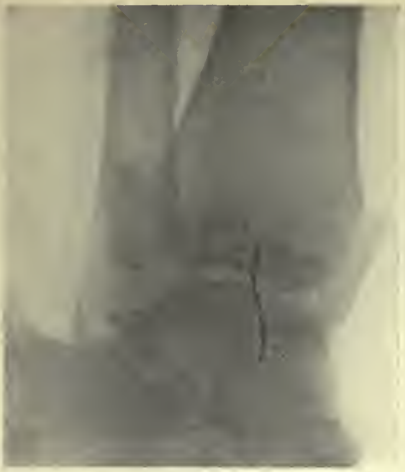

Fig. 21.

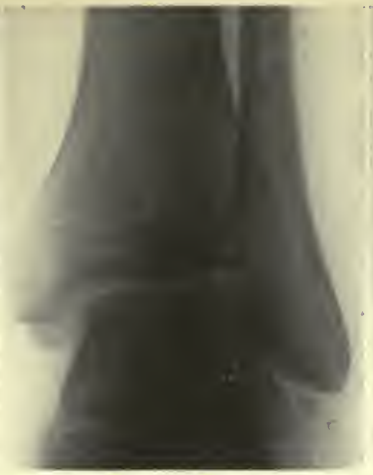

Fig. 22.

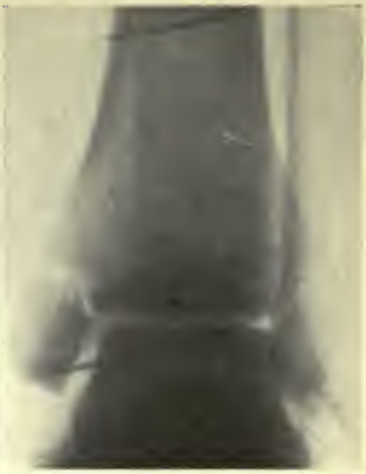

Fig. 23.

Fig. 21. Shows the characteristic forward displacement of the internal malleolus which we claim is diagnostic of an eversion fracture when the internal malleolus is broken. Rarely is it present in the inversion type; 41.3 per cent of our series, where the internal malleolus was broken, showed this displacement, and this represents all of the cases without ruling out those showing no displacement or the ones clearly due to inversion which should be excluded.

Fig. 22. Type 1.—Inversion fracture. Middle fasciculus of external lateral ligament is injured. Periosteal insertion fracture. This is common but escapes attention many times because not X-rayed. Of little importance—5.6 per cent represent our series. But this is not the true sequence. This is probably numerically the most common of all injuries at the ankle.

Fig. 23. Inversion. Type 2.—The stress falls at base of the internal malleolus which breaks, the break many times running upward. The malleolus is displaced inward or inward and backward if at all, but unlike eversion breaks, it is rarely displaced forward. Fibula intact. Many times it is impossible to tell so that these figures represent only those clearly inversion, but it is certain that inversion breaks of this type are more common (3.2 per cent of our series).

strain or sprain in the great majority of cases. A serious inversion injury including a break of one or both bones is escaped many times because if the ankle turns inward, the man applies to himself involuntarily the principle of jiu jitsu. In other words, he gives with the force and falls, thus distributing the force and many times saving himself from injury. The fall itself may break his neck, but not once in fifty times does he break his ankle. Many times he does strip a slight periosteal tear at the origin of the external lateral ligament and the reason for this is that inversion of the foot causes an easier separation of the external astragalocalcaneal joint and is the only manœuver by which one can put on strain the middle fasciculus of the external lateral ligament. The interosseous astragalocalcaneal ligament is also strained but rarely is there fracture in this type of injury, the man saving himself by going in his entirety with the force, falling forward and sideways in every case. Glance at Figure 9 and you will see how the separation of this external calcaneo-astragaloid joint is possible in inversion of the foot. In the anatomy we have already pointed out that the tarsal bones in inversion are capable of much greater latitude than in eversion; and this mobility, together with the jiu jitsu movements are the reasons for the lesser number of inversion fractures.

Try it with your foot, both in the position of inversion and eversion, the weight on the foot under strain, and see how easily you can give in the inversion position and how impossible it is with an everting foot, with the line of gravity internal or external to the ankle undergoing trauma.

Many of these periosteal tearing fractures of the tip of the external malleolus are never X-rayed and therefore our statistics are of no value, but it is extremely probable that this type of fracture would be the largest, numerically, of all the injuries to the ankle joint.

If this does not happen, if the force is too great or is not disseminated quickly enough, there is a transfer of stress to the internal malleolus.

Ext malleolus chip

old bone fragment on medial malleolus

Now, on this side, there are no ligaments to give and distribute the stress. The internal malleolus is an integral part of the bony structure of the tibia and it will break exactly at the point which is the resultant of all the stresses and these are exactly the same reversed, as was described in the mechanics of eversion, the center of gravity of the man's body being somewhat external to the internally twisting ankle. Sometimes the center of gravity is in line with the ankle or slightly internal to it but if it remains so, the stress is always mild. The first stress is trying to lever off the internal malleolus inward by pressure against it; and the second, the rotating stress is exerted on the internal malleolus from before back and on the external malleolus from behind forward.

There is no stress in this form of injury tending to pry the external malleolus directly outward as in the eversion type. Then why should the external malleolus break at all if the ordinarily accepted mechanics is the correct one? Yet we know that it does. Is this breaking of the external malleolus in inversion fractures due to avulsion of the malleolus by the external lateral ligament as is claimed by most writers?

The external malleolus itself is not broken in that manner any more than the internal malleolus is broken by avulsion in eversion types. The tibia is under compression as we have shown and the astragalus can not turn. There is no such lever of eccentricity as in eversion but there is static compression and impact which is many times the static compression. The break is because of the rotation which does furnish a stress against the external malleolus in this type of injury not alone to push it outward but especially to stress it from behind forward. And this stress is transmitted to the inferior tibiofibular ligaments not to such an extent, but nevertheless the same as in the eversion type.

If the fibula breaks, or if the inferior tibiofibular ligaments give, as both do at times, there is no redistribution of force against the internal malleolus possible and the break comes at the level of the joint. If the foot is in extreme dorsiflexion at the time, the force of impact acts exactly as in the other case against the anterior articular rim of the tibia and aided by the rotation force, it is apt to tear off the internal malleolus at the joint level. If the foot is in plantarflexion, the impact is taken up by the posterior portion of the tibia and the same forces are apt to split off a larger part of the tibia with the internal malleolus. After this comes internal or internal and posterior displacement of the astragalus. Nearly always, the internal malleolus is broken at the joint level and the external malleolus, if broken at all, is fractured oftener at the level of the joint (see Fig. 26). A break high up in the shaft of the fibula is rarer, but may be due exactly, as in the eversion type, to loose or broken inferior tibiofibular ligaments that permit a transfer of fulcrum higher up than the ligamentous insertion (see Fig. 27).

The fibula is often subjected to direct violence with the fall and a fracture of this bone may occur from this local direct violence at any point along the shaft. In our series, it will be seen that in the type where the fibula was broken, the high break was in proportion to the low break as 1 is to 2; a far greater percentage than in the eversion type. Backward dislocation is a far more frequent accompaniment of this type of injury and is probably due to the greater stress suffered in serious cases because of the greater latitude of movement at the various articular surfaces in this position. The very same factor which in a mild stress enables a man to save his joint from any injury, in a serious stress probably acts to increase the force because even the slight increase of latitude due to the articular separation possible in this position gives an added momentum to the stress.

A tack with ten or twenty pounds of weight superimposed does not sink into wood, but if it is struck through an arc of even one or two inches with a one-pound hammer it can be driven home. Thus, in our series of 249 cases there were 138 cases of fracture of the fibula alone, and outward dislocation of the foot was 21.01 per cent of the fractured fibula cases; while dislocation was 65.3 per cent of those cases which had suffered a fracture of both

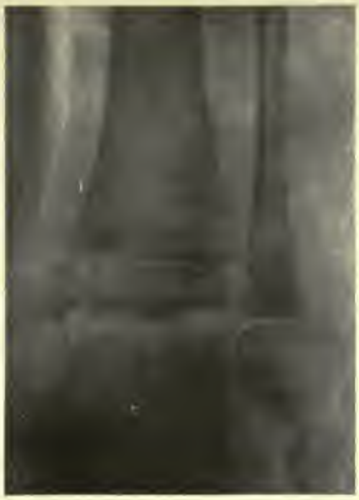

Fig. 24.

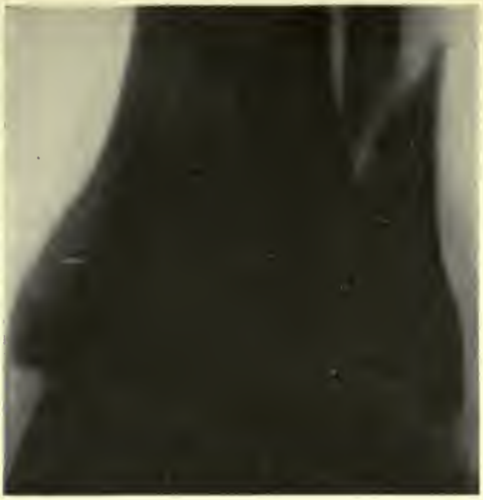

Fig. 25.

Fig. 24 (at left). Type 2.—Inversion. Same as Figure 19, but with displacement and dislocation in a young subject.

Fig. 25. Type 3.—Inversion. A very rare type, the tendency being to break the internal malleolus and thus free the pressure, or to break both bones simultaneously. If, however, as occasionally happens, the internal malleolus resists the strain, the external malleolus may be broken alone either at the joint or above as in this case. This is much more apt to happen if the foot is in extreme plantarflexion, because, in dorsiflexion, there is the tendency to anterior dislocation and the points of contact are more apt to be relieved from pressure, especially if anterior dislocation occurs. In plantarflexion the posterior outer edge of the astragalus is raised so that the contact with the external malleolus is greater and a rotating stress is more apt to catch it, the pressure being from behind forward. The existence of this type has been denied, nevertheless occasionally it occurs. Rupture of the inferior tibiofibular ligaments sometimes saves the fibula from fracture.

bones. Of the fractured fibula cases, alone, not one presented any great posterior displacement; while only 6 per cent showed any appreciable posterior displacement even where both bones were broken. Of the clearly inversion fractures, however, 32.3 presented posterior displacements of the foot; and if we rule out the simple periosteal tears of the tip of the fibula in which obviously no dislocation could take place, then 70 per cent of these cases of inversion fractures were posteriorly dislocated and an equal number were inwardly dislocated. Where both bones were fractured in inversion every case was dislocated.

Glance at Figure 26 and you will see what a tremendous injury is possible from simply stepping from a 4-inch curbing with inversion of the foot.

There remains to be considered only the splits of the tibia which occur both alone and as complications and these ordinarily may be divided into three classes:

1. Posterior splits of the tibia with or without other injury. These are extremely common (see Fig. 29).

2. Anterior splits of the tibia which are rarer than the posterior, but by no means uncommon (see Fig. 31).

3. Longitudinal splits which run up the bone for some distance without being complete. These are in the nature of what is known as slips in mechanics and are comparatively rare.

All these splits of the tibia are due primarily to impact and they are always a compression phenomenon in which the impact, in contradistinction to static compression, is the main causative factor and the split to a great degree is determined by the position of the foot. Is it dorsiflexed? Is it plantarflexed? If you will glance at the articulated skeleton, you will see that with the astragalus in the position of plantarflexion, the point of contact with the articular surface of the tibia will fall posteriorly; and if the os calcis is subjected to tremendous impact with the foot in this position, the force will be transmitted through the astragalus directly against the posterior articular surface of the tibia. If the impact is severe enough, a split involving this posterior surface of the tibia will result or there may be a broken astragalus or os calcis. Now while the main features of production are impact and the lever of eccentricity, there are other features which will influence, to a certain degree, the extent and direction of these splits both posterior and anterior. If you will glance at Figures 8 and 10 or at the articulated skeletal foot, you will see that as we have stated in the anatomy, the posterior edge of the tibia is a rough double curve and that therefore it forms a shoulder of bone projecting downward from the tibiofibular articulation and extending from this articulation to the groove for the flexor longus hallucis tendon.

Beyond the groove for the flexor longus hallucis, the posterior articular edge sweeps downward again to become continuous with the posterior surface of the internal malleolus. In the anatomy we also showed that the articular surface of the tibia at the tibiofibular junction receives the astragalus deeper than at any other point and with a foot undergoing injury (the astragalus under compression being held firmly against this articular surface and also twisted, as we have shown) (see Figs. 5 and 6) with the foot in plantarflexion and therefore the contact between the astragalus and tibia posterior, there would result a resistance to this twisting stress to which the astragalus is subjected at this bony projecting surface (see arrow 1, Fig. 10).

Were the stress an eversion stress there would be resistance not alone where the astragalus is twisting against the internal malleolus (arrow 3, Fig. 10), but also a stress against this projection of tibial bone backward and inward nearer to the tibiofibular articulation and this would tend to split off the entire posterior articular surface of the tibia either separately or as a large piece integral with the internal malleolus because this stress in eversion would tend to break the tibia from the point just below the tibiofibular articulation, running inward across the tibia. The breaking internal malleolus, the force of the impact, the lever of eccentricity, and other features might determine the extent of this split but this would be the tendency of an eversion stress.

It is curious that rarely do the posterior splits tearing off a wedge of bone posteriorly involve the internal malleolus. The split of the internal malleolus is one break and the posterior split is usually a separate break, especially when the injury is from inversion. Rarely do they come together and the posterior occurs frequently where there is no involvement of the internal malleolus. Such a break shows in Figure 18, the internal malleolus remaining intact.

With a stress in inversion and plantarflexion, the twisting astragalus would subject this protuberance of bone to strain in the opposite direction; the split in this case tending to run upward from the flexor longus hallucis groove a variable distance but splitting out a piece posteriorly involving the inferior tibiofibular articulation. In this latter case the posterior split would not have the same tendency to be integral with the broken off internal malleolus.

With the foot in dorsiflexion, we get no such stresses on the posterior articular rim of the tibia. Here the astragalus is wedged up against the anterior surface of the tibia and the lever of eccentricity is no longer posterior.

On the anterior articular rim of the tibia we also have a point of resistance or a lip which extends downward just external to the junction of the tibia with the internal malleolus but it is small (see A of Fig. 7). The anterior surface of the tibial lip receives the impact directly through the astragalus in the position of dorsiflexion and especially with eversion the twisting astragalus may form an additional stress by resistance against this anterior lip, the anterior split tending to be smaller than the posterior and extending outwardly from the point of resistance toward the fibula.

A true slip does not occur in bone but a resemblance exists in the comparatively rare phenomenon of a longitudinal split extending a variable distance up the center of the bone

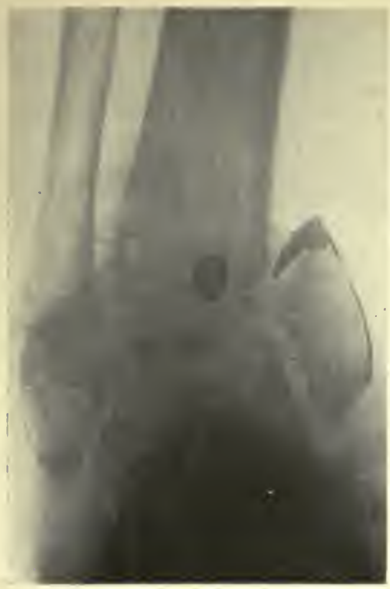

Fig. 26.

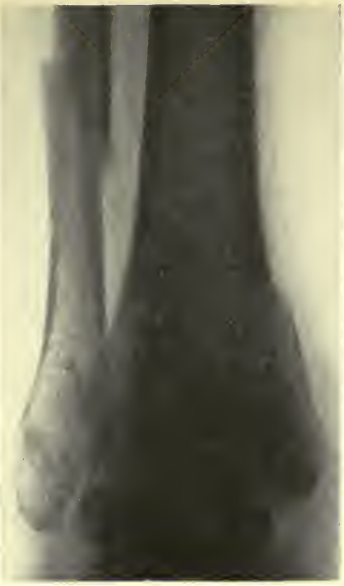

Fig. 27.

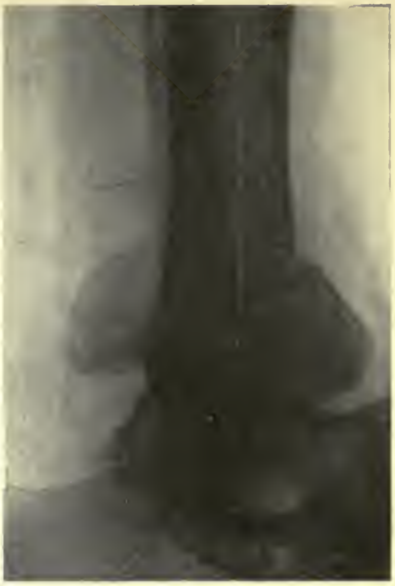

Fig. 28.

Fig. 26. Type 4, A. Inversion. Inversion fracture of fibula and internal malleolus. Often accompanied as here with impact complications. The fracture of the fibula is at the joint level and the internal malleolus at the joint level but often includes a large piece integral with the malleolus. Many times dislocation internal and posterior. It is obvious that a recovery here is only possible by operation and even then doubtful. Quick motion here is out of the question.

Fig. 27. Type 4, B. Inversion. The fibula is broken high up. The large piece integral with internal malleolus shows. Internal dislocation is reduced, but there is still backward dislocation. Reduced, this fracture will respond almost as quickly as one apparently much less serious. (Sub. Div. A and B represent 3.6 per cent.)

Fig. 28. Central split of tibia breaking out both anteriorly and posteriorly with telescoping. This is an operative case and result is extremely doubtful. To apply motion quickly to such a case, even if it could be reduced without operation, or to apply any fixed rule would be, of course, absurd.

due to impact where the foot is nearly at right angles to the tibia and when the contact between the astragalus and tibia is central. Sometimes these splits result in very severe injuries. The split starts as a slip, runs up the middle of the shaft and then breaks out on both sides of the cortex separating two large pieces from the lower end of the shaft of the tibia; and the astragalus promptly separates them widely by telescoping them (such a break shows in Fig. 28).

The split of the posterior surface of the tibia is important only if the split surface is large involving a great amount of the articular surface and thus tending to permit a recurrence of the posterior displacement of the astragalus, but it is a condition easily dealt with by hyperdorsiflexion of the foot.

The anterior split is of much greater importance as the possibility of a new growth of reparative bone in this location might well tend to reduce dorsiflexion to a minimum, thus interfering with the stair climbing movement of the ankle joint. This also is dealt with in the same way. Extreme hyperdorsiflexion and motion are used here earlier than in the posterior split in order to get the full range of dorsiflexion and prevent the fragment from becoming permanently anchored in such a position as to restrict motion; but care must be used not to push up the anterior fragment too much.

CLASSIFICATION

If we are to abandon the old nomenclature, how shall we classify these various injuries?

SIMPLE FRACTURES

Simple fractures of the fibula or fractures of both bones of leg from direct violence are neither eversion nor inversion fractures. They are due to direct violence or to simple cross breaking strains and are not to be considered under compression leverage fractures.

COMPRESSION LEVERAGE FRACTURES OR INJURIES OF THE ANKLE

Compression leverage fractures may be divided into two classes: (1) eversion, (2) inversion.

Eversion Fractures

Type 1. Simple periosteal tear of internal lateral ligament or that portion of internal lateral ligament that runs from tip of internal malleolus to sustentaculum tali of os calcis. In 249 cases it was observed only twice. This is the simplest form of eversion injury at the ankle joint and is extremely rare. It is interesting as it shows that occasionally there is some separation of the internal astragalocalcaneal joint (Fig. 12).

Type 2. Fracture of the external malleolus alone half way between the joint surface and the tip. This is an eversion leverage fracture due to the impingement of the external articular rim of the os calcis as the os calcis slides outward on the astragalus and the rim of the articulation brings up against the tip of the external malleolus. Such a fracture is usually due to a stress of low intensity and direct eversion, the twist being in abeyance. The external malleolus breaks half way on the transverse ligament as a fulcrum. Displacement is not usual. The mortise of the ankle joint is usually not damaged to any great extent, the inferior tibiofibular ligaments not being ruptured. Weight bearing may be begun early. Dislocation of the foot is not possible and does not take place unless the inferior tibiofibular ligaments are ruptured, which is very rare (Fig. 13).

Type 3. Fracture of the internal malleolus from eversion (Figs. 14 and 15). There are in reality two types:

Sub. Div. A. The mildest type is usually the result of the rotation stress, the foot being in extreme dorsiflexion so that the strain falls on the portion of the internal malleolus anterior to the notch and results in a break below the joint level.

If the inferior tibiofibular ligaments are not ruptured, which is often the case, there is no dislocation possible and the type is no more serious than Type 2. This type often occurs when the compression stress is not on the foot and we have called this type "the Polo fracture" because we have had several which were produced by the opponent's horse, catching the foot of the man and twisting it outward. Where the compression feature is not in evidence, it is possible that there is a certain amount of turning motion possible to the astragalus which permits the internal edge of the astragalus to drop: thus making these half way breaks more likely (Fig. 14).

Sub. Div. B. (See Fig. 15.) The internal malleolus is broken at the joint level. The fibula is unbroken but many times the inferior tibiofibular ligaments are ruptured. If so, dislocation of the foot outward is possible and is many times present. The fragment of the internal malleolus is displaced outward by the pull of the internal lateral ligament, if dislocation of the foot occurs. Fracture of the fibula does not occur because the tibiofibular ligaments give way first and distribute the stress, or the stress is comparatively mild and is disseminated with the break of the internal malleolus.

Type 4. (Figs. 16 and 17.) Sub. Div. A. Fracture of fibula, alone at level of joint. More frequently the split runs upward, and backward, due to the combination of stresses, outward and from before backward. This is clearly a leverage fracture with the potentiality of displacement, whether or not it occurs. It is due to three stresses: eversion of the foot, the astragalus being crowded over against the external malleolus, and exerting pressure outward; a rotating force by which an additional stress is brought to bear against the external malleolus from before backward, and which accounts for the backwardly displaced lower fragment of the fibula which is observed so many times; and third, the compression stress which is present in all these cases, due to the weight of the man plus impact. The inferior tibiofibular ligaments are always injured in this type of case and often completely ruptured. Eccentricity being always on the fibula side bringing the acme of stress to this side, accounts for the preponderance of fibula fractures.

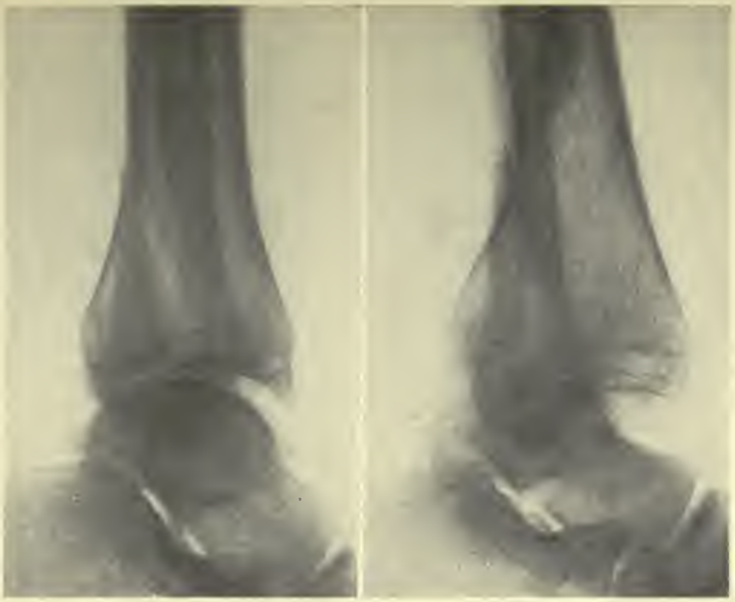

Fig. 29. Fig. 30.

Fig. 29 (at left). Impact splits of tibia. Posterior split with fragment forced upward. No dislocation of the ankle. These may occur alone or as complication of any of the other types. This is the result of impact in plantarflexion.

Fig. 30. Impact split of tibia. Posterior with great posterior dislocation. Anterior and posterior 1.8 per cent of ankle fractures alone; 11.2 per cent as complication of other fractures. Longitudinal splits of the tibia are occasionally encountered.

In our series of 249 cases, 55.4 per cent were fractures of the fibula alone, and 42.1 per cent belong to this type of our classification.

Type 4. Sub. Div. B. (Fig. 18.) The fibula broken alone but higher up than the joint level. Same mechanics as A, and all other conclusions pertaining to A apply to B. The high fracture of the fibula is explained in this article, and is more likely to occur in that form of eversion injury where the center of gravity is outside the stressed foot. Only 4.8 per cent of our series fall in this group.

Type 5. Fracture of fibula and internal malleolus. Sub. Div. A. (Fig. 19.) The fracture of the fibula being at the joint level. The same mechanics as Type 4 and the same conclusions apply. The fractured internal malleolus is a matter of small importance unless so badly displaced as to resist replacement. The internal malleolus is many times displaced somewhat forward, a feature which we contend is always a proof of the eversion character of the injury (Fig. 21). Dislocation, as in Type 4, is a potentiality, whether or not it occurs. The internal malleolus is nearly always broken at joint level: 13.6 per cent.

Type 5. Sub. Div. B. (Fig. 20.) Fracture of the fibula high up and fracture of internal malleolus at or near level of joint as usual. The same mechanics as A of Type 5 and as Type 4, and same conclusions, apply; 6.4 per cent fall into this class. This is the classical Pott's

Inversion Fractures, 13.6 per cent

Type 1. (Fig. 22.) Insertion fracture, periosteal tear of the external lateral ligament. A small chip of bone is separated from the tip of the fibula by the stress suffered by the middle fasciculus of the external lateral ligament. This is a most common type of injury and is caused by the easy separation of the external calcaneo-astragaloid joint, when the foot is inverted. In our series, there were 5.6 per cent but it is probable that this form of injury represents the largest type of injuries to the ankle, since it is probable that few of these cases are X-rayed. The injury is simple, and a few days of restriction is all that is usually required with subsequent care.

Type 2. (Figs. 23 and 24.) Inversion fracture of the internal malleolus. This is a common type of inversion fracture. The stresses are not distributed, the strain comes against the base of the internal malleolus—the same three stresses which we have mentioned in the production of the eversion types but in this case reversed. No such lever of eccentricity is present on this side, however, except posteriorly, sometimes, and, therefore, the fracture of the internal malleolus is a sheer fracture, usually; the compression, however, preventing the astragalus from turning. The fracture begins at the joint surface and either runs transversely or up to include a somewhat larger piece. Compressional splintering is not present on this side.

Dislocation of the foot is a potentiality, whether or not it occurs. The fragment is displaced inward, if displaced at all, and sometimes backward, but, unlike the eversion type, is not likely to be displaced forward. This represents a differentiation, where the history is not clear.

Rupture of the inferior tibiofibular ligaments may occur, but is less likely than in the eversion types of injury. Of this type 3.2 per cent represent our series, but this is clearly erroneous, because many times where displacement or dislocation does not occur, the history will not be clear. Many more of these cases were caused by inversion than are shown by these figures, but fracture of the internal malleolus alone, is, nevertheless, more often the result of eversion than of inversion.

Type 3. (Fig. 25.) Fracture of the fibula from inversion either at the joint or high up. This is rare, but happens occasionally. The inferior tibiofibular ligaments are usually injured, but dislocation rarely occurs.

Type 4. Fracture of fibula and internal malleolus. 3.6 per cent clearly inversion.

Sub. Div. A. (Fig. 26.) Broken fibula and internal malleolus. Fibula at joint level. The same mechanics reversed as for the same type of eversion fracture. If displacement of the fragments occurs, the internal malleolus is not displaced forward, as in the eversion type, and, unless the foot dislocates, the lower fragment of the fibula is not so likely to be displaced backward. Dislocation is common, however, changing the picture.

Type 4. Sub. Div. B. (Fig. 27.) Fracture of fibula high up and fracture of internal malleolus. In our series this was less frequent than the Sub. Div. A, in the proportion of 1 to 2. Exactly the same mechanics apply here, and the same conclusion may be drawn. Dislocation is common, and backward dislocation is a more common accompaniment of inversion fractures than of eversion.

There is another type of injury to the ankle joint, usually the result of rotation, which, without a solution of continuity of any osseus structure, presents much the same condition, inasmuch as the inferior tibiofibular ligaments are ruptured, the mortise of the ankle joint is broken up, and dislocation is not only a potentiality, but is frequently present. Such a case is represented by Figure 11, and shows clearly the outward dislocation resulting from a broken inferior tibiofibular ligament. Inasmuch as soft tissue tends to heal more quickly than bony tissue, no such period of immobilization is necessary, but restriction of motion and weight bearing for a time is absolutely essential to the restoration of the efficiency of the astragalo-tibiofibular mortise.

TREATMENT

Reduction where there is dislocation is the important point and is usually easy of accomplishment. Even in the simple cases of fractured fibula from eversion either low down or high up, the same force which produces the break is apt to displace posteriorly the lower fibula fragment and to displace the astragalus backward a little, which is often missed in the study of the X-ray plate, and disregarded in treatment. First, flex the knee. Rocking the foot usually suffices to correct the lateral displacement, but many of these minor posterior dislocations are not reduced. Direct pressure backward on the intact tibia above, and a strong pull forward on the tuberosity of the os calcis carrying the foot into hyperdorsiflexion. By so doing, we shall save the patient much subsequent discomfort. With direct pressure, we can also correct these backwardly carried inferior fragments of the fibula, and this is essential. Twist the foot inward and forward. It twisted outward and backward when it occurred. After reduction, there is very little tendency to displacement, unless a posterior split has occurred. If the internal malleolus is intact adduction is the position of choice, and may be held by any splint. Personally for the emergency we use a pillow splint tied with tapes and reinforced with pieces of splint wood or board, internal, external, and posterior. Below the foot, the open ends of the pillow case are folded and pinned, so as to keep the foot hyperdorsiflexed. If the position is satisfactory in the X-ray, we put on a Cabot splint, bending the knee always to keep the position of hyperdorsiflexion of the foot. This relaxes the gastrocnemius and solius muscles, which form the tendo achillis. A doughnut is placed under the heel always. No Pott's should be put into plaster at this time. The swelling is too great and the cast is always inefficient under these conditions. If the internal malleolus is broken, we do not invert the foot. We use a straight position. Inversion with a broken internal malleolus is an absurdity; worse than an absurdity, it is a menace.

Where the internal malleolus is broken and displaced, Magnuson of Chicago uses a small incision over the malleolus and pins it back into place with an ivory pin which he leaves. He believes that by this manœuvre, he restores the mortise of the joint, and that then he can place the foot in the position of inversion. We believe the reduction and the straight position are sufficient in most cases, but in a very limited number, where reposition of fragments is hard to obtain, this treatment is ideal.

We always have several pillows under the knee to keep it in the flexed position, thus rendering the hyperdorsiflexed foot comfortable. Only in those cases showing a large anterior split of the tibia which are rare, do we vary the hyperdorsiflexion of the foot. Even in these cases, we are careful to get the foot above a right angle, because we have found that this is one of the movements easily lost by disuse and slow in recovery. Keep the foot above a right angle with the leg, and you will have no difficulty, even where there is a tendency to new bone on the anterior edge of the tibia. If there is a posterior split of the tibia, it is essential to keep the foot dorsally flexed; a plantarflexed foot is apt not only to redislocate where the fragment is large and involves at least half the articular surface of the tibia; but it is apt to push upward the posterior fragment.

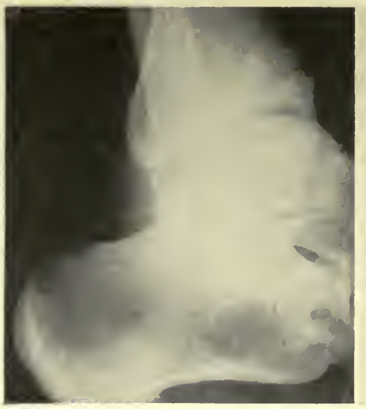
Fig. 31.

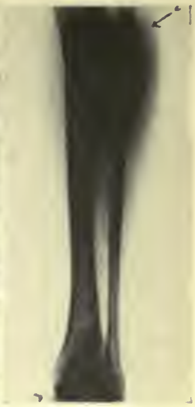
Fig. 32.

Fig. 31 (at left). Impact splits of tibia, anterior split. Due to impact with foot in dorsiflexion. Less frequent than the posterior splits.

Fig. 32. Meissonneuve's fracture, an eversion fracture, very rare. Fracture of the internal malleolus. Fracture of the fibula high up. Note fracture of fibula shows tortional stress. This is a compression fracture presenting no fundamental differences from the classical type as the height of the fibula fracture is not a matter of importance. Outward dislocation of foot.

Fortunately, these posterior splits are usually small and do not involve a great articular surface.

We begin motion, in most of these cases, by the third or fourth day in the ordinary type, and certainly by the end of the first week in nearly all of them, unless there is tremendous swelling or tremendous tearing of ligaments which only happens in the very serious cases. We believe that if one observes carefully, he will be surprised at how rarely this occurs. Every day, thereafter, the foot is gently moved passively and actively, the hyperflexed foot being carefully lifted from its splint by the toes, the knee kept well flexed. We follow the same manœuvre in all our cases whether the fibula is broken high up or low down. The broken internal malleolus simply means a greater degree of caution. Plantarflexion must never be carried to extremes. An arc of 20 degrees of motion at first is sufficient.

Dorsiflexion, actively and strongly, is essential, and effort is made by the patient early to dorsiflex his foot strongly, except in cases of anterior split. Even here, passive flexion within limits is used from the first.

In the case of posterior splits, be especially careful not to plantarflex too quickly or too far. In some few cases of great injury, we permit immobilization for 10 to 15 days with the toes free for movement, but in most cases we begin motion gently, not later than the fourth day. Thereafter, motion every day, and as passive is to be preferred to immobilization, so active motion, no matter how limited, is to be preferred to passive motion. Motion must be retained from the first, and can be so retained in practically every case, if care and intelligence are used in the manipulation. This is the point of the whole treatment. Restriction of motion—partial ankylosis—is due to organization of inflammatory products, and involvement of tendons, and tendon sheaths in the reparative scar tissue, together with a traumatic synovitis which is kept without motion. It is remarkable how quickly these immobilized ankles tend to stiffen. It is remarkable how quickly and easily and without pain they take up their functions, even in the face of tremendous trauma, if they are given a chance early. Do not let them stiffen. If you do, you will have impaired function for a long time.

By the end of the first week, or before, in nearly all of these cases, the swelling will be of such a nature that a cast is practicable. It should extend in the simple cases only a short distance up the leg. In the more serious, it should reach nearly to the knee.

If the internal malleolus is unbroken, the assistant holds the foot by the toes in strong inversion and hyperdorsiflexion with a flexed knee, while we are molding the cast. Get well above a right angle, and use a light cast.

The cast is put on, over stockinette, and the stockinette is not pulled over the foot. It is rolled over, thus preventing any undue pressure on the broken malleoli. A few small strips of metal are incorporated under the heel to prevent subsequent breaking and the cast is cut down the front, when sufficiently hard, a strip 1 inch in width being removed along the whole length and widened from the ankle forward to from 1.5 to 2 inches, so as to permit of easy removal. Many of these cases have a molded leather ankle splint by the end of the first week because of its lightness.

After the tenth to the twelfth day, all danger of damage to these injured ankles has passed, if we use care and all of them are in plaster or molded leather, the patient going about on crutches. After the first few days the simple cases are soaked in very hot water once a day, and carried through their exercises. We use the same treatment in these cases as we have advocated in Colles' fractures for many years, but with one difference. We have repeatedly made the statement that an ordinary Colles' fracture with anything for retention except a wrist strap after the tenth to fourteenth day was maltreated. We do not mean by that, that a patient who has suffered a Colles fracture can throw a base ball on the fourteenth day, or the twenty-first, but we do say that there being no weight bearing at the wrist, we may dispense with all restrictive apparatus, except the small leather wrist strap, very early. The same would apply to a Pott's except for three factors: the weight bearing; the weight of the foot itself anterior to the astragalus; and the pull of the gastrocnemius and solius muscles. These, then, must be considered. After the twelfth day, there is little danger of redislocation or damage to the broken parts provided we have no weight thrown upon the foot. We cannot permit weight bearing in any of these injuries at the ankle joint due to leverage until there is no possibility that that weight bearing will cause deformity by bending out the bones on the hinge of soft callus, which holds them together, and we must not permit this until such time as this soft callus has been replaced by bony tissue strong enough to resist the pressure which it will be called upon to bear.

This is an individual proposition and probably differs greatly in every person, so that we must not take chances. One bad result—one foot that turns out progressively after weight bearing—will more than counterbalance good results in a dozen cases. It is probable, in fact

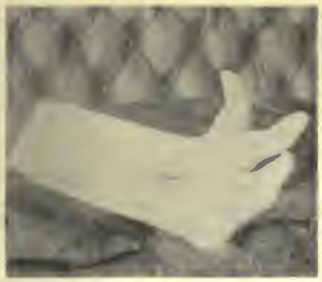

Fig. 33.

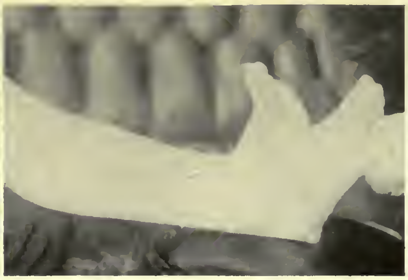

Fig. 34.

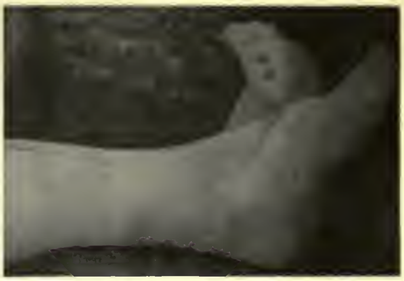

Fig. 35.

Fig. 33. (See Fig. 16 for X-ray.) Motion on tenth day and on all other days. No loss of motion at any time—nevertheless in this simple type swelling of the leg and ankle persisted much longer than in some of the apparently much more serious types. But motion remained good.

Fig. 34. (See Fig. 17 for X-ray.) Active motion without pain on the fourteenth day and thereafter. Note that here there is still a restriction to dorsiflexion, but not much; and not so much as is apparant here because the other foot shows the same.

Fig. 35. (See Fig. 19 for X-ray.) Active motion on fifteenth day and thereafter. Same degree of motion also showed much earlier, but photograph is on fifteenth day.

I am convinced, that many of these cases would receive no injury from weight bearing much earlier than we now permit, but, where the individual coefficient of repair is an unknown quantity, we must not take chances, and there is no necessity for so doing. With motion each day, by the twenty-first day, all these cases will be able to have a practically normal motion at the ankle, the simple ones much sooner. The ankle will swell and in some of them cyanosis will be pronounced, but they will all have the normal range with perhaps some slight restriction. So long as we preserve this normal motion against the day when we can, with absolute safety, permit of weight bearing, we shall have done all that is needed to do, since in this case they will be able to walk with ease when the time comes, instead of having the recovery of lost motion still before them.

In the simple case of a break of the external malleolus below the joint level, there is no tendency to eversion of the foot. Such a case needs practically no restriction, except care, and may bear some weight with care at almost any time, certainly by the twelfth or fourteenth day. A case of simple break of the fibula above the joint by direct violence, and not a leverage fracture, is held together by soft callus by the twelfth day. There is beginning actual bony growth across the break by the twenty-first day. There is little strain in weight bearing in such a case, and neither does it require a great amount of restriction. By the twentieth day, such an injury may safely begin to bear some weight, but care must be observed.

In a leverage fracture of the ankle joint, attended by ligamentous tear, and by the potentiality, at least of dislocation at the astragaloid joint, either by inversion or eversion, with fracture high up or low down of the fibula, by the fifteenth day, the foot should be out of the cast for an hour or two each day. It should be soaked in hot water, and active motion in flexion and extension should, by this time, reach a fairly normal range. No lateral motions should be permitted.

By the eighteenth day, only a light molded leather ankle strap should be used by day, the cast being used only at night, but the patient should be permitted to sit with the foot resting lightly on the floor, without weight and in the simple cases with a shoe raised $\frac{1}{4}$ to $\frac{1}{3}$ inch on the inner side, slight weight bearing may be begun by the twenty-first to thirtieth day, but no great amount of weight should be borne for at least 4 or 5 weeks. We must remember that with this treatment when he begins to bear weight, the surgeon has finished the case, and we can therefore afford to go slow. There are no long months of struggle before him for the completion of motion.

In the serious cases it is better to wait 6 weeks before weight bearing. It is safer to do so, and there is little to be gained, since the motion has not been lost. In the serious cases with great injury and dislocation, where the

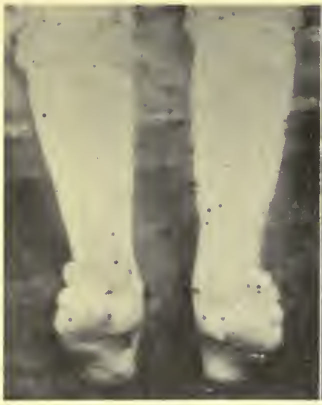

Fig. 36.

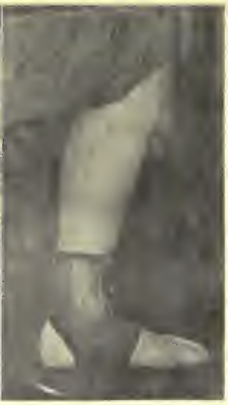

Fig. 37.

Fig. 36. (See Fig. 31 for X-ray.) Note dorsiflexion reached in this case on fourteenth day. No weight however is borne on the foot. It is simply resting here without weight.

Fig. 37. Moulded anklet used. After 15 days in simple cases, and after 21 to 25 days in the more serious. Patients sleep in the casts, or in special leather cases, at night. All patients wear this anklet. A shoe with raised inner side is worn in all cases of eversion fractures for at least two months.

man is very heavy, a steel support attached to a padded ring on the leg and inserted into the heel of the shoe may be used for several weeks after walking is permitted, but in the vast majority of cases, this will not be found necessary. The inverted foot and the ankle strap will be sufficient. A leather or a metal foot plate is sometimes added.

The inferior calcaneoscaphoid ligament, the spring ligament which is one of the important ligaments of the internal longitudinal arch, is rarely injured, but all muscles and ligaments are weak from disuse after a fracture of this kind. It is, sometimes, important to wear a foot plate, but it is of far greater importance to put the injured foot through a period of regular exercise, before weight bearing is permitted. This is the treatment which should be used in every case of fracture of the ankle, and, if used, will shorten the time of disability by months. It is unfortunate that in the unintelligent class of people, care will have to be used, and the casts left on for a longer period, because they cannot be trusted, and damage suits are, at present, far too common to be disregarded, but even in this case, where the casts (for reason of prudence) must be left for a much longer time than necessary, it is incumbent upon the surgeon to see that the mobility of the foot is preserved from the first.

In the eversion type, we always use a shoe which is made so that the inner side of the heel and sole make a straight line, as all shoes should be made, and long enough to sweep wide of the toes.

The inner side of the heel and sole are raised ¼ to ⅓ inch in order to invert the foot slightly. An inverted foot is always a strong foot, an everted one is always a weak one.

CONCLUSIONS

Leverage fractures of the ankle under compression are, in reality, all of the same etiology, and vary simply from distribution of force and intensity of stress. This applies to most of the so-called simple fractures of the lower end of the fibula since the salient features of this fracture are present: i.e., ligamentous and tendon injury and a destroyed mortise permitting dislocation. Simple fractures of the fibula at any level, the result of direct violence without ligamentous rupture, do not belong to this type, but there are no compression leverage fractures of this kind involving the ankle joint.

The inversion types are not usually attended with so great a destruction of ligaments, but there is an equal or more serious involvement of tendon sheaths, and a greater posterior dislocation is common in our experience.

The majority of these fractured ankles are not tremendously serious injuries and do not deserve the bad repute which is theirs at present. The bad results have been the result of immobilization and misdirection of effort on the part of the surgeon.

Motion, active and passive, from the very beginning is the solution of the problem. Do not permit the ankle joint to stiffen in the first place. This is easy to prevent. It is only overcome, once it has occurred, at the expense of tremendous effort and months of time.

It is easy to reduce an ankle fracture, put it in a cast and look at it once a week, but it is fatal to the patient. If time is too important for one to devote 20 minutes a day to his ankle fractures, he had better turn them over to some other surgeon. No masseur is com-

249 ANKLE INJURIES—ALL KINDS EXACTLY AS THEY CAME

I

	Cases	Per cent
Fibula alone	138	55.4
Broken high	12	4.8
Half way	7	2.8
Clearly at joint or near it	105	42.2
Periosteal tears from inversion	14	5.6
Ankle dislocated at joint	29	11.6

11.6 of whole or 21.01 per cent of number with fibula broken.

II

	Cases	Per cent
Fibula and internal malleolus	52	20.9
Fibula broken:		
High	16	6.4
Half way	1	.4
At joint or near	34	13.6
Periosteal tear	1	.4
Internal malleolus broken:		
At joint level	45	18.
Low	7	2.81
Dislocation of ankle	34	13.6 of whole series or 65.4 per cent of this class.
Internal malleolus displaced anteriorly	23	9.2

III

	Cases	Per cent
Internal malleolus alone	35	14.
At the joint level	26	10.4
Below half	7	2.81
Periosteal tear	2	.8
Dislocation of foot	12	4.8 of whole or 34.3 per cent of this type.
Internal malleolus displaced forward indicating eversion	13	5.2

IV

	Cases	Per cent
Fractured fibula and separated tibial epiphysis	5	2.
Dislocated foot	4	.....

V

	Cases	Per cent
Fractured scaphoid, alone	2	.8
As complication	2	.....

VI

	Cases	Per cent
Fractured astragalus, alone	5	2.
As complication	2	.....

VII

	Cases	Per cent
Fractured os calcis	5	2.

VIII

	Cases	Per cent
Dislocated foot without fracture	3	1.2
Forward	2	.8
Outward with ligament rupture	1	.4

IX

	Cases	Per cent
Impact splits of tibia, alone	4	1.6
As complication	28	11.2

X

	Cases	Per cent
Total dislocation of the ankle, all cases	87	34.9

XI

	Cases	Per cent
Clearly inversion fractures	34	13.6
Periosteal tears of fibula	14	5.6
Periosteal tear, fibula and broken internal malleolus as well	11	4.4
Broken internal malleolus, alone	8	3.2
Broken astragalus from impact in inversion	2	.8
Broken fibula and internal malleolus	9	3.6
Fibula high	3	
Fibula at joint	6	

Ruptured inferior tibiofibular ligaments clearly as evidenced by wide separation of the bones in the X-ray plate, 30 cases, 12.05 per cent.

Many others undoubtedly were ruptured but when the X-ray evidence was not conclusive they were excluded.

petent to do this work unless he is a surgeon and also competent to remedy any bad result. In the hands of a man who understands the pathology of the lesion, however, there is no danger.

From both the standpoint of economics and compensation insurance, this is a tremendously important subject. The time lost now, as a result of this injury, is enormous. It often extends over periods of months, or even a year or more, in individual cases, and this applies unfortunately to the mild type as well as the severe. Multiply this by the number of ankle fractures in a single year, and the time lost will be found to be enormous. A fracture of this type, without complications, should be returned to light employment in from 4 to 7 weeks, with a practically normal foot, except for some swelling which in certain cases will persist for a long time.

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